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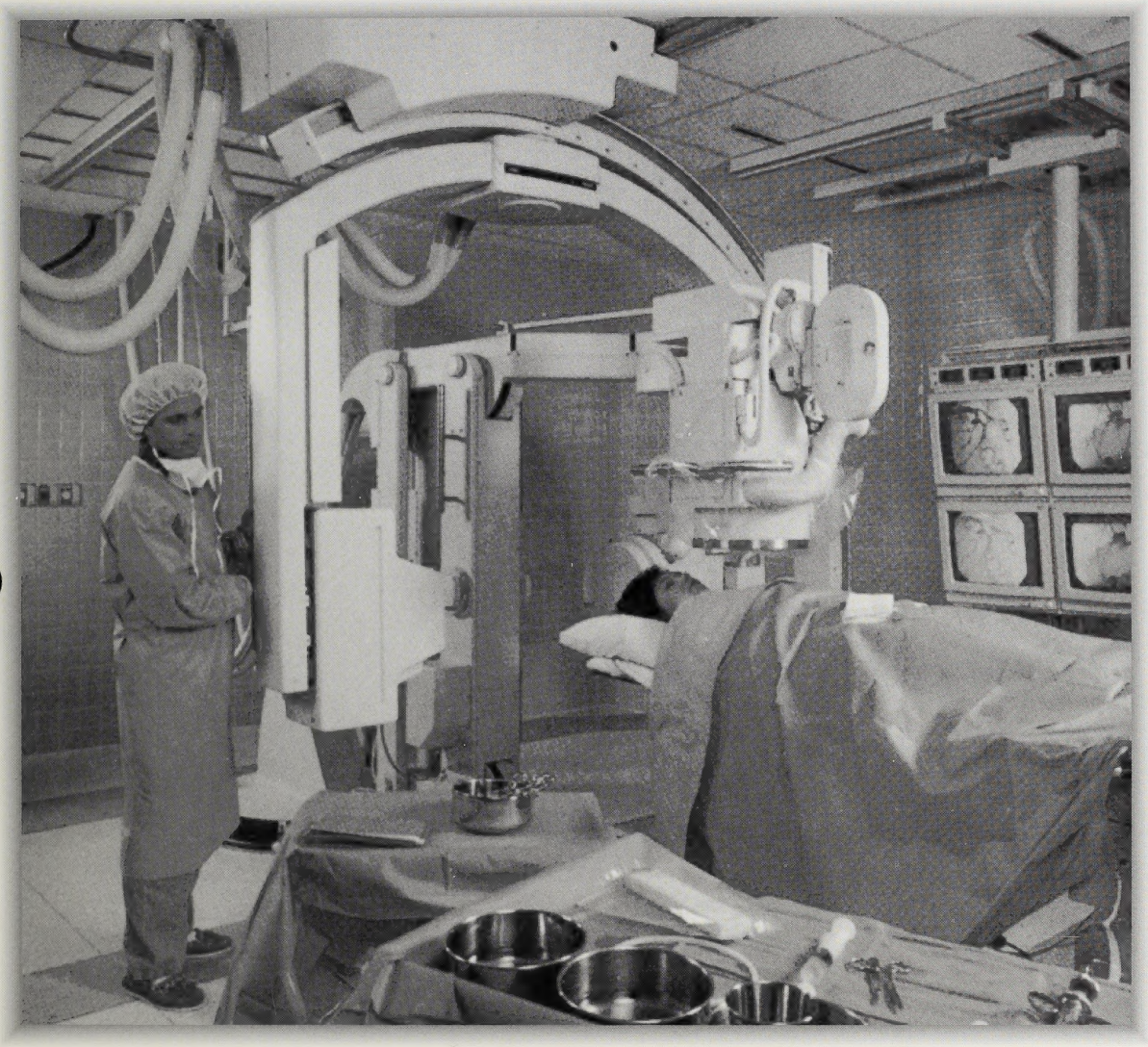
Science 30



MODULES 1–8

Learning Facilitator's Manual

Distance Learning

Alberta EDUCATION

NOTE: This Science 30 Learning Facilitator's Manual contains answers to teacher-assessed assignments and the final test; therefore, it should be kept secure by the teacher. Students should not have access to these assignments or the final test until they are assigned in a supervised situation. The answers should be stored securely by the teacher at all times.

This document is intended for	
Students	
Teachers (Science 30)	✓
Administrators	
Parents	
General Public	
Other	

Science 30
Learning Facilitator's Manual
Modules 1–8
Alberta Distance Learning Centre
ISBN 0-7741-1109-7

Cover photo: NASA

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Teachers

Register with the Alberta Distance Learning Centre

The Alberta Distance Learning Centre is dedicated to upgrading and continually improving your Learning Facilitator's Manual so that it accurately reflects any necessary revisions we have had to make in the Student Module Booklets, Assignment Booklets, or the sample final test. The types of revisions that will be made are those that make the course more accurate, current, or more effective.

The ADLC will send you the **latest enhancements** or **minor upgrades** for your Learning Facilitator's Manual if you return the following registration card to: Alberta Distance Learning Centre, Box 4000, Barrhead, Alberta T7N 1P4, Attention: Instructional Design and Development.

ADLC Learning Facilitator's Manual
Registration Card

First Name _____ Surname _____

School Name _____ School Phone Number _____

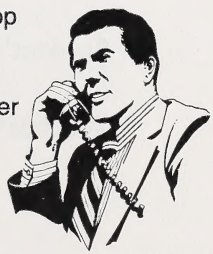
School Address _____

City _____ Postal Code _____

Course Title _____ Approximate Date of Purchase _____

You can help ensure that distance learning courseware is of top quality by letting us know of areas that need to be adjusted. Call the Alberta Distance Learning Centre free of charge by using the RITE line and ask for the Editing Unit. Also, a teacher questionnaire has been included at the back of most Learning Facilitator's Manuals. Please take a moment to fill this out.

We look forward to hearing from you!



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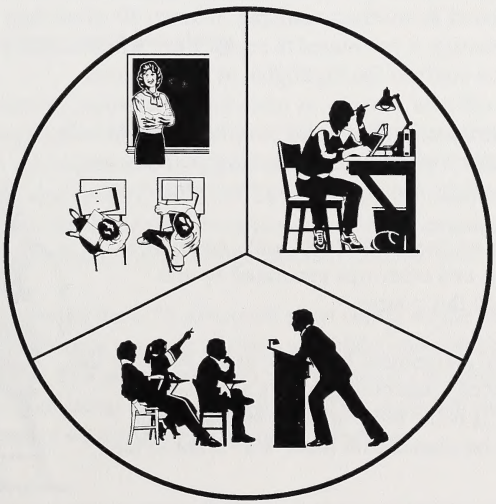
Teacher Questionnaire

Introduction

A survey of these course materials will confirm that this new learning package has been specially designed for many kinds of teachers working in a variety of situations.

In Which Category Do You Fit?

- ❑ Small Schools Teacher
  - ❑ inexperienced
  - ❑ experienced, but in other subject areas
  - ❑ experienced in teaching Science 30, but wanting to try a different approach
- ❑ Distance Learning Teacher
  - ❑ travelling to schools within the jurisdiction
  - ❑ using facsimile and teleconferences to teach students within the area
- ❑ Large Schools Teacher
  - ❑ inexperienced
  - ❑ experienced in teaching Science 30, but wanting to try a different approach



Because these materials have been created by experienced classroom teachers and distance learning specialists, they have many advantages for students and teachers regardless of their situations.

Advantages for Students

- incorporates a strong learner-centred philosophy
- promotes such qualities in the learner as autonomy, independence, and flexibility
- is developed through media which suit the needs and circumstances of the learner
- reflects the experiential background of Alberta students
- opens up opportunities by overcoming barriers that result from geographical location
- promotes individualized learning, allowing learners to work at their own pace

Advantages for Teachers

- allows teachers maximum teaching time and minimizes preparation time
- includes different routes through the materials to suit different learners
- incorporates a wide range of teaching strategies, in particular those using independent and individual learning
- delivers curriculum designed by education specialists that reflects the Alberta Education Program of Studies with an emphasis on Canadian content
- provides learning materials which are upwardly compatible with advanced educational technology

Does it sound like something you could use?

This Learning Facilitator's Manual begins with an overview of the current Alberta Education Program of Studies for Science 30. This summary is included for inexperienced teachers or those teachers who have found themselves teaching Science 30 when their training is in other subject areas. This brief summary is not meant to replace the Alberta Education Program of Studies, but rather to help teachers confirm the highlights of the program.

Other parts of this introduction have also been included to help teachers become familiar with this new learning package and determine how they might want to use it in their classroom.

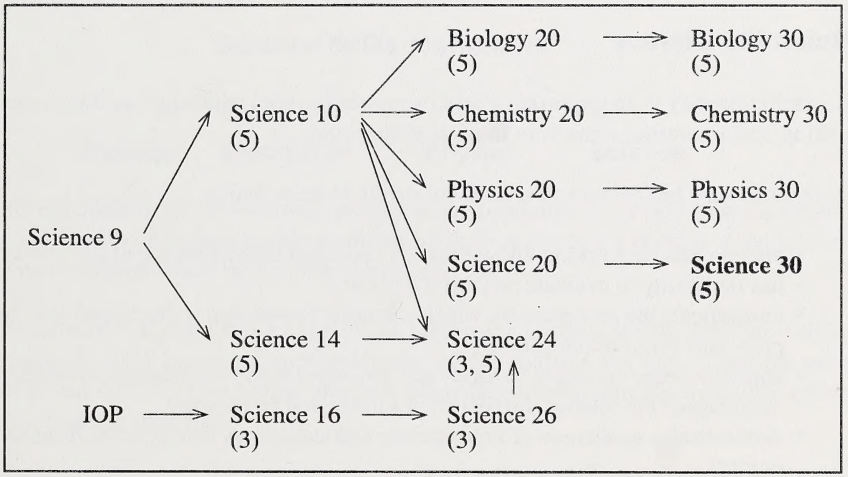
Beyond the introduction the guide itself contains answers, models, explanations, and other tips generated by the teachers who authored this course.

The module booklets, assignment booklets, and LFMs are the products of experienced classroom teachers and distance learning specialists. It is the hope of these teachers that their experience can be shared with those who want to take advantage of it.

Overview of the Program of Studies

The Science 10/20/30 program is the result of Alberta Education's Secondary Education Review of 1985. The policy set forward by this review established new requirements for high school graduation. High school students are now required to complete a minimum of two science courses (8 credits) to obtain a General High School Diploma and three science courses (15 credits) to obtain an Advanced High School Diploma. The Science 10/20/30 program was designed to provide a well-rounded science education for those students who choose to take the minimum number of credits in science for the Advanced High School Diploma.

The following diagram illustrates the various course sequences in the Senior High Science Program. Credit values are provided in brackets beneath each of the courses shown on the diagram. Notice that Science 30 follows in sequence from Science 10 and Science 20.



[1]

Science, Technology, and Society

The 1985 policy statement, *Secondary Education in Alberta*, also directed the new high school science program to emphasize the application of basic scientific concepts and principles in the real world. The new high school science program has achieved this by emphasizing the interrelationship of science, technology, and society, (STS). The STS approach is intended to provide Alberta students with a more balanced science education, one with an emphasis on science in the real world, rather than focussing on a body of knowledge isolated from its social context.

The teaching of science using the STS approach must centre on the development of scientifically literate and responsible citizens capable of using scientific knowledge wisely for the good of all members of society. The STS approach to science challenges students by developing scientific literacy through experimentation and investigation. This approach motivates students to learn more about science and to apply what they learn to other situations.

[1] Senior High Science Teacher Resource Manual, Curriculum Branch, 1992.

Technology is often the main point of contact individuals have with science. High school students are intrigued by the ever-developing gadgets and processes that characterize our age. There is therefore a tremendous opportunity, when dealing with the relationship between science and technology, to make the subject come alive. Science deals with gravity and friction, but technology gives us the wheel. While science asks "why?", technology asks "how?". Science is aimed at increasing human understanding and ability to explain nature. Technology is aimed at developing devices or processes that have practical purposes.

Science and technology affect every aspect of the daily life of Canadians. Both science and technology are involved in areas as diverse as communications, travel, agriculture, and waste management. But what is science and what is technology? Are they the same or are they different? How do science and technology affect society? How does society control science and technology? If students are to become enlightened, contributing citizens in a constantly changing society they will need to know the answers to these questions.

Scientific Literacy

Scientific literacy is an important goal of secondary school education, as it provides a means for asking and answering some very important questions.

A scientifically literate person has the following characteristics:

- demonstrates a working knowledge and practical understanding of the sciences
- has the ability to evaluate scientific evidence
- understands the processes by which scientific knowledge is developed and can adapt those processes for personal use
- applies science concepts, theories and processes to the investigation of everyday problems
- understands the relationship between science and technology
- demonstrates awareness of how science and technology can function responsibly in a social context
- recognizes the limitations as well as the usefulness of science and technology in advancing human welfare
- demonstrates a continuing interest in science and technology.[1]

An Integrated Science Curriculum

The Science 10/20/30 program uses an integrated approach to science education that is organized around themes which transcend the artificial boundaries of traditional science disciplines. This integrated approach more accurately reflects the current nature of science, with major advances now occurring in interdisciplinary areas such as geophysics, astrophysics, biophysics, and biochemistry. The integrated science approach is built on the premise that the fundamental concepts, skills, and attitudes of science are common to all scientific disciplines.

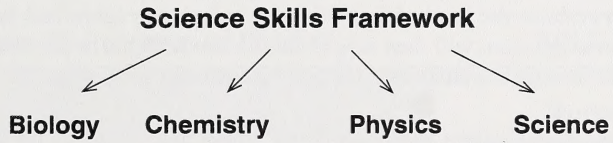
The Science 10/20/30 program allows teachers to explore many areas of science with their students instead of being restricted to one particular discipline.

[1] Senior High Science Teacher Resource Manual, Curriculum Branch, 1992.

The fundamental or key concepts in Science 30 are change, diversity, equilibrium, matter, energy, and systems. These conceptual themes provide teachers with a means of showing the connections among scientific disciplines to students. The conceptual themes also provide a frameowrk that students can use to see how individual sections of the course relate to the big ideas of science. The major themes in Science 30 are energy and systems.

The skills and attitudes developed in the Science 10/20/30 program also enhance the integration of themes. Students should come to realize that there are scientific process skills which are common to all disciplines. Skills such as questioning, hypothesizing, designing experiments, and gathering, processing, and interpreting data are universal in their importance to science and scientific research.

Teaching science using an integrated approach means reducing the sheer amount of material covered, fostering a scientific way of thinking, and paying more attention to the interactions of science, technology, and society.



The development of the new science programs has necessitated a review of assessment methods. Since the growth of science problem-solving skills in students is a priority of the science curricula, assessment methods must reflect this emphasis.

The document, *A Model for the Assessment and Evaluation of Scientific Problem-Solving Skills*, Draft, June 8, 1992, has direct implications for ADLC students and school students using distance learning materials. The following proposal attempts to incorporate the evaluation scheme into distance learning materials.

There are six categories in which the science skills of students will be assessed:

A. Initiating and Planning
B. Collecting and Recording
C. Organizing and Communicating
D. Analysing
E. Connecting, Synthesizing, and Integrating
F. Evaluating the process or Outcomes

Each category will be assessed according to a level scheme as discussed in the document. This scheme will need to be explained to students. Each course will have a standard explanation outlining the assessment model in Module 1.

Each course will have a science skills spreadsheet that allows students to record their progress in completing the science skills component of selected assignment questions throughout the course. The Science 30 spreadsheet is in the Appendix of Module 1. Science skills could be evaluated in the context of a lab investigation, a research project, a case study, or a group project. The framework for scientific problem-solving skills is explained in the Appendix of Module 1.

Each course will have to ensure that students have opportunities to be evaluated in each of the skills. In addition, students will need to be given formative practice at developing the skills throughout the activities and investigations. **Note:** The skill level indicated by the teacher to the student in the assignment questions is **NOT** reflected in the mark of the questions.

The evaluation of these skills will be ongoing throughout each science course. Students will be encouraged to do self-evaluation as well as a summative evaluation that focuses on growth and improvement.

Self-Evaluation

- When students do the activities in their module booklets, the science skills icon will reinforce which skills are being practiced. Students will be encouraged to reflect on their skill level.

- When students complete a question in the assignment that focuses on a science skill, they will be asked to evaluate the level of their response before it is submitted for grading. The teacher marking the assignment will then supply the student with his or her evaluation of the response along with a concise explanation if the level is different from what the student suggested.

- This area of self-evaluation will be explored further and enhanced for the 30-level courses.

- Self-evaluation concludes by students analysing their own progress as displayed on the spreadsheet. A mark will be given for this spreadsheet upon its completion. Each time their assignments are returned, the students are expected to transfer both the teacher level assessment and their own level assessment to the spreadsheet.

Summative Evaluation

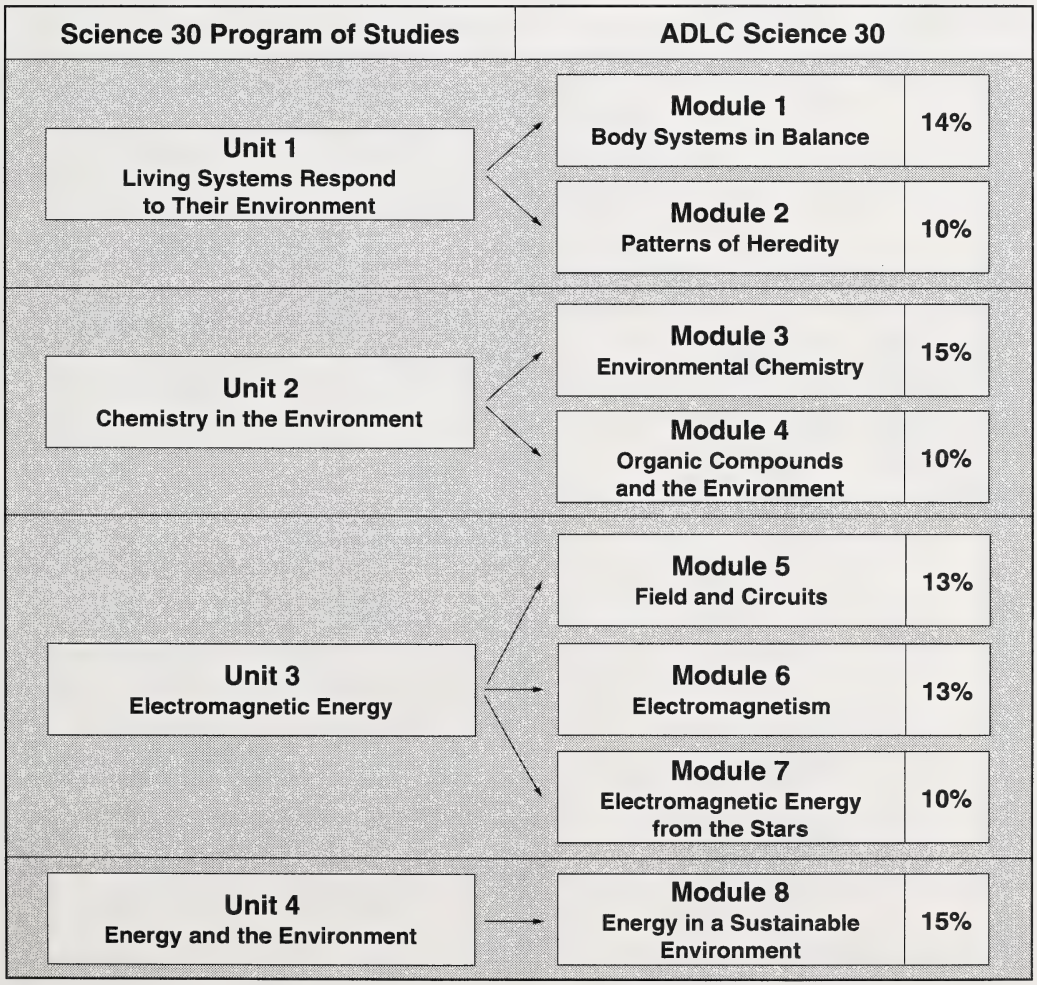
- The level of a student's performance will be determined by the teacher throughout the course. As shown in Self-Evaluation, the level of performance for a particular science skill or set of skills will be assessed in the assignment questions that have been "flagged."

- The students will carefully track their progress throughout the course by recording their level and the teacher's level of assessment of achievement on their spreadsheet. The teacher will keep an on-going record of all teacher level assessment.

Overview of Science 30

The ADLC Science 30 course is made up of eight modules. Modules 1 and 2 involve the study of human living systems and the mechanisms that enable these systems to respond to their environment. Modules 3 and 4 involve the study of the role of chemistry in environmental studies with emphasis of the impact of acids, bases, and organic compounds on the ecosystem. Modules 5 and 6 involve the study of electromagnetic energy and its use in communication and scientific research, whereas Module 7 extends the study of electromagnetic energy to include the stars and the entire universe. Module 8 examines the range of renewable and nonrenewable energy sources and considers the impact of their use on the global ecosystem.

The sequence of modules follows the Science 30 program of studies as outlined by the Curriculum Branch, Department of Education. The following graphic illustrates the relationship between the program of studies and the Science 30 program as produced by the Alberta Distance Learning Centre. The recommended percentage of available instructional time is also given for each module.

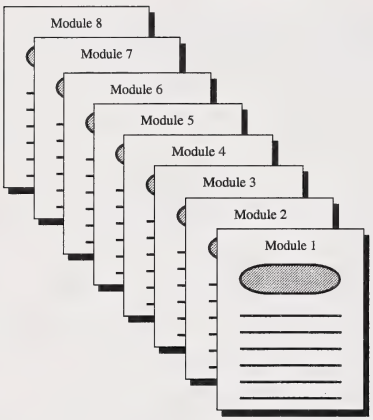


Structure of the Learning Package

Basic Design

This new learning package involves many other components in addition to the Learning Facilitator's Manual.

Modules



The print components involve many booklets called modules. These modules contain guided activities that instruct students in a relevant, realistic setting.

The modules have been specially designed to promote such qualities in the learner as autonomy, independence, and flexibility. Writers have incorporated such teaching strategies as working from the concrete to the abstract, linking the old to the new, getting students actively involved, and using advance, intermediate, and post organizers. Many other techniques enable learners to learn on their own for at least some of the time.

The structure of the module booklets follows a systematic design. Each module begins with a detailed table of contents which shows the students all the main steps. It acts as an organizer for students. The overview introduces the module topic or theme. A graphic representation has been included to help visual learners and poor readers. The introduction also states the weightings of each assignment.

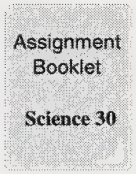
Contents
Overview Evaluation
Section 1 Activity 1 Activity 2 etc.
Section 2 Activity 1 Activity 2 etc.
Section 3 Activity 1 Activity 2 etc.
Section 4 Activity 1 Activity 2 etc.
Module Summary

The body of the module is made up of two or more closely related sections. Each section contains student activities that develop skills and knowledge centred around a theme.

The activities may involve print, audio, video, computer, or laser videodisc formats. At times the student and the learning facilitator are allowed to choose the activity that best suits the student's needs and interests. Other activities such as the Extra Help and Enrichment are optional pathways. This flexibility caters to each student's personal situation.

The summary focuses on the skills and strategies that the student has learned.

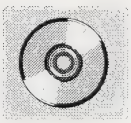
Assignment Booklet



Accompanying each module is an assignment booklet. The activities in these booklets can be used for formative and for summative assessments. The students should complete these assignment booklets when they have thoroughly reviewed the module materials. The assignment booklets have been designed for classroom use, for faxing, or for mailing. **If the booklets are not being mailed, you should remove the outside cover.**

Media

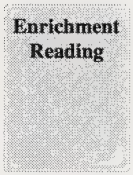
VIDEOCASSETTE



LASER VIDEODISC

The package also includes references to media. There are activities that require students to view certain videos. These mandatory videos are listed on the following page. It is important that you acquire these videos as you are planning the course. In addition to the mandatory videos, optional videos have been mentioned at various points in the modules. A list of the optional videos is also included on the following page. More information about the videos can be found within the LFM.

Textbooks and Reference Books

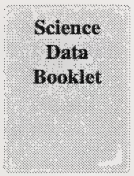


This package requires students to use *Visions 3*, published by Gage, as their textbook. Additional references are indicated later in this manual.

Lab and Other Materials

The package includes references to lab materials. A list of necessary materials is included later in this manual.

Science Data Booklet



A Science Data Booklet is included in the Appendix of Module 1 and in the LFM final test.

Materials, Media, and Equipment

Mandatory Components

Equipment (Hardware)	Media	Materials
• VCR	• Mandatory Video List: – *Healthy Choice, Healthy Hearts*, Alberta Heart and Stroke Foundation – *The Human Body: Respiratory and Circulatory System*, ACCESS Network – *The Immune System: Your Magic Doctor*, ACCESS Network – *Human Body: Nervous System*, ACCESS Network – *Protein Synthesis—Part 3, DNA Replication*, ACCESS Network – *Planet Under Pressure: Acid Assault*, ACCESS Network – *Hazardous Waste Management: Alberta Success Story*, Alberta Special Waste Management Corporation, Vicom – *Organic Chemistry 2, Soaps and Detergents*, ACCESS Network – *Science, Technology and Society, Toxic Wastes (Toxilla)*, Alberta Education, ACCESS Network – *Electricity: Conductors and Insulators*, ACCESS Network – *Electromagnitism: The Motor Principle*, ACCESS Network – *Electromagnetism: Magnetism and Electron Flow*, ACCESS Network – *Electromagnetism: Domain Theory*, ACCESS Network – *Electromagnetism: Electromagnetic Induction*, ACCESS Network – *Wave-Particle Quality: The Electromagnetic Model*, ACCESS Network – *Nuclear Physics, The Discovery of Radioactivity*, ACCESS Network – *Nuclear Physics, The Properties of Becquerel Rays*, ACCESS Network – *Nuclear Physics, Natural Transmutations*, ACCESS Network	• LFM for Science 30 • one complete set of module booklets (8) and assignment booklets (8) for each student • There is a final test.

Videocassettes used in the course may be available from the Learning Resources Distributing Centre or ACCESS Network. You may also wish to call your regional library service for more information.

Optional Components

Equipment (Hardware)	Media	Materials
• VCR • laser videodisc player	• Optional Laser Videodisc List: – *The Living Textbook: Life Science (Side 2)*, Perceptix Inc. • Optional Video List: – *Homeostasis: The Sea Within*, ACCESS Network – *Planet Under Pressure: Ozone*, ACCESS Network – *Acid Rain: A North American Challenge*, ACCESS Network – *Acid-Base Indicators*, *Chem Study* (Ward's 2nd ed.) – *The Athabasca: A Case Study*, Alberta Education, ACCESS Network – *Science, Technology & Society, After the Flush, Parts I and II*, Alberta Education, ACCESS Network – *Electromagnetism: Earth's Magnetic Field*, ACCESS Network – *NASA Space: New Universe*, ACCESS Network – *NASA Space: Universe*, ACCESS Network – *Nuclear Power*, Classroom Video (1991) – *Nuclear Physics*, Classroom Video (1991)	

Using This Learning Package in the Classroom

Conventional Classroom

Whether your classroom has desks in rows or tables in small groups, you may be most comfortable with a learning system that you can use with all your students in a paced style. In other words, you may want a package that will suit all of your students, so they can move through the materials as one group or several small groups. Because these materials contain different routes or pathways within each module, they can address various learning styles and preferences. The materials also include many choices within the activities to cater to different thinking levels and ability levels. Because of their versatility and flexibility, these materials can easily suit a conventional classroom.

Open-Learning Classroom

Open learning is the concept of opening up opportunities by overcoming barriers of time, pace, and place by giving the learners a package specially designed to enable them to learn on their own for at least some of the time.

Such a concept is not new. Many teachers can recite attempts to establish an individualized learning system as they recognized the importance of trying to personalize courseware to meet each individual student's needs. But these efforts often failed due to lack of time and lack of quality materials that conformed to Alberta specifications.

Due to advanced educational technology and improved Alberta-specific learning packages, a student-centred approach is now possible. Improved technology now allows us to provide support to learners individually, regardless of their pace or location. A teacher cannot be in twenty-eight places at one time offering guidance. However, media and a well-designed learning package can satisfy individual needs. Technology can also help provide an effective management system needed to track the students as they progress independently through the materials.

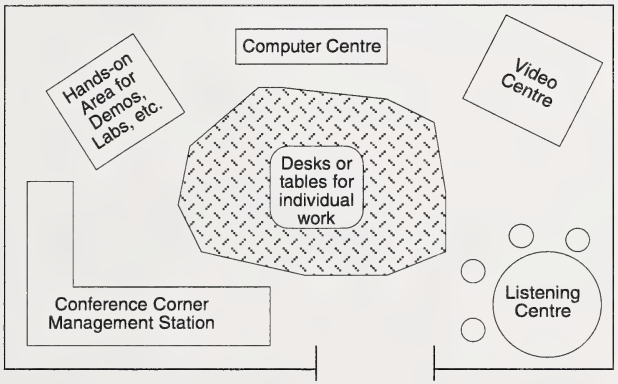
The key to a successful open-learning system depends on three vital elements: a learning package specially designed to enable students to learn effectively on their own for at least some of the time; various kinds of learner support; and a management system and style that ensures that the open-learning system runs smoothly.

The Key to a Successful Open-Learning System

Learning Package

The specially designed learning package needed for a successful open-learning system has been developed for you. The objectives teach current Alberta specifications using strategies designed for individualized instruction. As the learning facilitator, you need to be sure to have all the components in the learning package available to students as needed.

If adequate numbers of media are available to satisfy the demand, a centre can be established for specific media.



You may not have the luxury to have enough hardware to set up a permanent video or computer centre in your classroom. In that case, students should be encouraged to plan ahead. Perhaps every three to five days they should preview their materials and project when they would need a certain piece of media. This would allow you to group students, if necessary, or reserve media as required.

Support

Support is definitely a key element for successful learning, and when you're planning an individualized, non-paced program, you need to carefully plan when and how support will be given.

The materials contain a form of consistent support by providing immediate feedback for activities included in the module booklet. High school students have solutions, models, explanations, and guides included in the appendix of every module booklet. These are included so students can receive immediate feedback to clarify and reinforce their basic understanding before they move on to higher levels of thinking.

As the learning facilitator, you may be needed to offer more personal guidance to those students having difficulty, or you may need to reinforce the need for students to do these activities carefully before attempting the assignments in the assignment booklet.

The activities include choices and pathways. If a student is having difficulty, you may need to encourage that student to work on all the choices rather than one. This would provide additional instruction and practice in a variety of ways.

Another form of support is routine contact with each individual. This might be achieved with a biweekly conference scheduled by you, or as students reach a certain point (e.g., after each section is completed), they may be directed to come to the conference area.

Special counselling may be needed to help students through difficult stages. Praise and encouragement are important motivators, particularly for those students who are not used to working independently.

Direct teaching may be needed and scheduled at certain points in the program. This might involve small groups or a large group. It might be used to take advantage of something timely (e.g., election, eclipse, etc.), something prescheduled like the demonstration of a process, or something involving students in a hands-on, practical experience.

Support at a distance might include tutoring by phone, teleconferencing, faxing, or planned visits. These contacts are the lifeline between learners and distance education teachers, so a warm dialogue is essential.

Management

Good management of an open-learning system is essential to the success of the program. The following areas need action to ensure that the system runs smoothly:

- Scheduling, Distributing, and Managing Resources – As discussed earlier, this may require a need for centres or a system for students to project and reserve the necessary resources.

- Scheduling Students – Students and teachers should work together to establish goals, course completion timelines, and daily timelines. Although students may push to continue for long periods of time (e.g., all morning), teachers should discourage this. Concentration, retention, and motivation are improved by taking scheduled breaks.

- Monitoring Student Progress – You will need to record when modules are completed by each student. Your data might also include the projected date of completion if you are using a student contract approach.

Sample of a Student Progress Chart

Science 30		Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Final Test
Billy Adams	P									
	A									
Louise Despins	P									
	A									
Violet Klaissian	P									
	A									
P = Projected Completion Date A = Actual Completion Date										

The student could keep a personal log as well. Such tracking of data could be stored easily on a computer.

- Recording Student Assessments – You will need to record the marks awarded to each student for work completed in each module assignment booklet. The marks from these assignment booklets will contribute to a portion of the student's final mark. Other criteria may also be added (a special project, effort, attitude, etc.). Whatever the criteria, they should be made clear to all students at the beginning.

Sample of a Student Assessment Chart

Science 30	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Year's Average	Final Test	Final Mark
Billy Adams	**67**	**65**	**54**	**47**	**78**	**67**	**72**	**57**	**63**		
Louise Despins	**43**	**50**	**54**	**55**	**48**	**42**	**52**	**45**	**49**		
Violet Klaissian	**65**	**65**	**66**	**68**	**67**	**70**	**68**	**69**	**67**		

Letter grading could easily be substituted.

- Recording Effectiveness of System – Keep ongoing records of how the system is working. This will help you in future planning.

Sample of a System Assessment Chart

Module 1			
Date	Module Booklet	Assignment Booklet	Resources/Media

The Role of the Teacher in an Open-Learning Classroom

The teachers in a conventional classroom spend a lot of time talking to large groups of learners. The situation in open learning requires a different emphasis. Teachers will probably meet learners individually or in very small groups.

With this approach it is necessary to move beyond the idea of a passive learner depending largely on a continually supportive teacher. The teacher must aim to build the student's confidence, to stimulate the learner into self-reliance, and to guide the learner to take advantage of routes that are most meaningful and applicable to the learner.

These materials are student-centred, not teacher-centred. The teacher needs to facilitate learning by providing general support to the learner.

Evaluation

Evaluation is important to the development of every learner. Data gathering and processing, and decision making, at the student and teacher level, serve as means of identifying strengths and weaknesses.

These specially designed learning packages contain many kinds of informal and formal evaluation.

Observation

In the classroom the teacher has the opportunity to see each student perform every day and to become aware of the level and nature of each student's performance.

Observations are more useful if they are recorded in an organized system. The following list of questions is a sample of types of observations and how they can be collected.

Observation Checklist

	B. Adams	L. Despins	V. Klaissian	H. Smith	K. Dalley
1. Does the student approach the work in a positive manner?					
2. Is the student struggling with the reading level?					
3. Does the student make good use of time?					
4. Does the student apply an appropriate study method?					
5. Can the student use references effectively, etc.?					

Observation may suggest a need for an individual interview with a student.

Individual Conferences

Individual conferences may be paced (scheduled) by the calendar, at certain points in the module, or they may be set up only as needed or requested.

During these conferences teachers can determine the student's progress and can assess the student's attitudes toward the subject, the program, school, and self, as well as the student's relationship with other students. With guided questions the teacher can encourage oral self-assessment; the student can discuss personal strengths or weaknesses in regard to the particular section, module, or subject area.

Self-Appraisal

Self-appraisal helps students recognize their own strengths and weaknesses. Through activities that require self-assessment, students also gain immediate feedback and clarification at early stages in the learning process. Teachers need to promote a responsible attitude toward these self-assessment activities. Becoming effective self-assessors is a crucial part of becoming autonomous learners. By instructing, motivating, providing positive reinforcement, and systematically supervising, the learning facilitator will help students develop a positive attitude toward their own progress.

For variation, students may be paired and peer-assessing may become part of the system. The teacher may decide to have the student self-assess some of the activities, have a peer assess other activities, and become directly involved in assessing the remainder of the activities.

When the activities have been assessed, the student should be directed to make corrections. This should be made clear to students right from the start. It is important to note the correct association between the question and the response to clarify understanding, aid retention, and be of use for study purposes.

Many of the activities include choices for the student. If the student is having difficulty, more practice may be warranted, and the student may need to be encouraged to do more of the choices.

Each section within a module includes additional types of activities called Extra Help and Enrichment. Students are expected to be involved in the decision as to which pathway best suits their needs. They may decide to do both.

Self-appraisal techniques can also be introduced at the individual conferences. Such questions as the following might be included:

- What steps are you taking to improve your understanding of this topic?
- What method of study do you use most?
- How do you organize your material to remember it?
- What steps do you follow when doing an assignment?
- What could you do to become an even better reader?
- Do you have trouble following directions?
- Did you enjoy this module?

A chart or checklist could be used for recording responses.

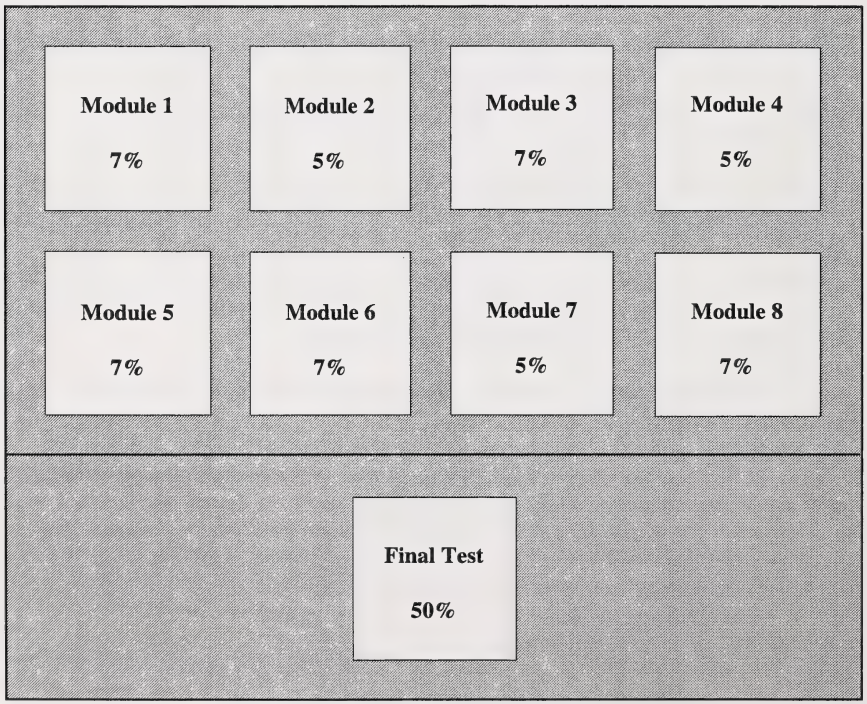
Informal Evaluation: Assignments

Informal evaluation, such as the assignments included in each module, are an invaluable aid to the teacher. They offer ongoing assessment information about the student's achievement and the behaviour and attitudes that affect that achievement.

Each module contains a separate booklet called the Assignment Booklet. This booklet assesses the knowledge or skills that the student has gained from the module. **The student's mark for the module may be based solely on the outcome of learning evident in the assignment booklet; however, you may decide to establish a value for other variables such as attitude or effort.** It is important that you establish at the beginning which outcomes will be evaluated, and that all students clearly understand what is expected.

Final Test

All LFMs include a formal final test which can be photocopied for each member of the class. The test, closely linked to the learning outcomes stated in the module booklets, gives the teacher precise information concerning what each student can or cannot do. Answers, explanations, and marking guides are also included. The value of the final test and each module is the decision of the classroom teacher. Following is a suggestion only.



Introducing Students to the System

Your initiation to these learning materials began with a basic survey of what was included and how the components varied. This same process should be used with the class. After the materials have been explored, a discussion might include the advantages and the disadvantages of learning independently or in small groups. The roles of the students and teacher should be analysed. The necessary progress checks and rules need to be addressed. Your introduction should motivate students and build a responsible attitude toward learning autonomously.

Skill Level

It is important for students to understand that there are certain skills that they will need in order to deal successfully with the course materials. They are listed below:

- understanding and using instructional materials (table of contents, index, list of illustrations, WHMIS labels associated with lab materials, appendices, bibliography, and glossary)
- interpreting lab data, maps, graphs, and charts
- using reference materials
- utilizing science skills
- using a scientific calculator
- communicating in a precise and effective manner

Other general skills are using reliable study methods, outlining, and learning to read at a flexible rate.

To decide the level and amount of instruction needed to accommodate the varied levels among students, you may wish to prepare and administer skill inventories or pretests. If most students need help with a particular skill, you may want to plan a total class instructional session. If only certain students lack a skill, you may want to set up a temporary skill group to help students who need it, or you may want to develop a skills file for this purpose.

Reading Level

These course materials are largely print based, but poorer readers need not be discouraged. It is important that you assure the students that these materials have been designed for easy reading. The authors have employed special strategies that lower and control the reading level. Some of them are

- the conscious selection of vocabulary and careful structuring of sentences to keep the materials at an independent reading level
- the integration of activities, examples, and illustrations to break text into appropriate-sized chunks
- the inclusion of many kinds of organizers (advance, graphic, intermediate, concept mapping, post organizers) to help give students a structure for incorporating new concepts

- the recognition that vocabulary and concepts are basic to understanding content materials and, thus, must be handled systematically (defined in context, marginal notes, footnotes, and often in a specialized glossary)

- the acknowledgement that background knowledge and experience play a vital role in comprehension

- the systematic inclusion of illustrations and videos to help poorer readers and visual learners, and audiocassettes and software as an alternative to print-based learning

- a variety of formats (paragraphs, lists, charts, etc.) to help poorer readers who do not absorb or retain main ideas easily in paragraph format

- the inclusion of media and activity choices to encourage an active rather than passive approach

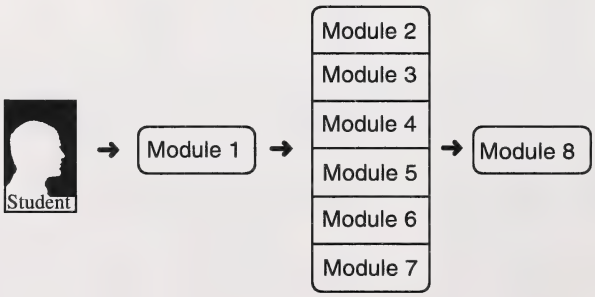
- instruction in a meaningful setting rather than in a contrived, workbook style

- using purposeful reading, viewing, and doing to produce better interpretation of the course materials

- the recognition that students need structured experiences when reading, viewing, or listening to instructional materials: developing pupil readiness, determining the purpose, providing guided instruction and feedback, rereading if necessary, and extending (This structure closely resembles the reading process.)

To help make the learning package more readable, you can begin your module preparation by reading (viewing, listening to) all the related materials that are going to be used. You need a solid background in order to assess and develop a background knowledge for students. The students' experiential bases may be assessed through brainstorming sessions concerning the topic, or by using visuals and guided questions to predict what the topic might be about.

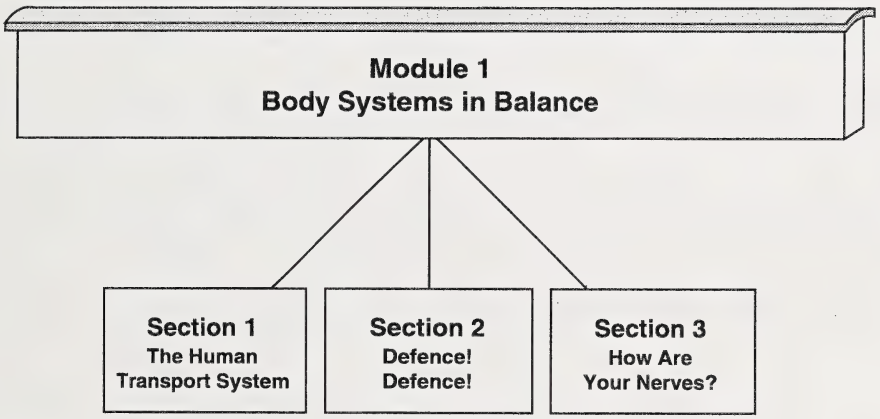
It is recommended that you start with Module 1 because this module includes basic introductory information, and it is also recommended that you end with Module 8 because this module acts as a summary or culmination.



Module 1: Body Systems in Balance

Overview

The main focus in this module is the human organism and how its various body systems maintain equilibrium with the environment. It is divided into three sections. The first section consists of four activities. This section is concerned with the structure of the circulatory system, as well as the role of blood and homeostatic regulatory mechanisms controlling cardiac output and blood pressure. The second section consists of three activities. It examines the human body and the defence mechanisms it has to protect itself from disease-causing organisms and environments. The section contains three activities. It focuses on the structural and functional role of the skin in defence and protection. It also examines the cellular and noncellular components of the human immune system. The third section takes a look at the nervous system and how it mediates the interaction of humans with their environment. It consists of four activities. The section will involve the study of the sense organs and how information is communicated from the sense organs to the brain or spinal cord to cause a response to maintain equilibrium. The first activity focuses on the neuron and the nerve impulse. The second activity examines the senses of sight, balance, and touch. The third activity discusses the organization of the nervous system. The fourth activity looks at the reflex arc and compares it to a learned response.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**35 marks**
Section 2 Assignment	**30 marks**
Section 3 Assignment	**35 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

The following is a list of materials and equipment necessary for an individual to complete the investigations and activities in Module 1. Adjust the amount of equipment if more than one individual is involved.

Section 1: Activity 2

- Precise Photographic Guide of the Pig Heart

Section 1: Activity 3

Investigation: The Nature of Blood Flow in Capillaries and Veins

Part A

Pathway A

- live goldfish or guppy
- petri dish
- cloth or paper towels
- medicine dropper
- glass of water
- magnifying glass or microscope (if available)

Pathway B

- diagram of fish tail and information in Observations section

Part B

- yours or a friend's forearm
- pencil and paper

Section 1: Activity 4

Investigation: Looking at Blood

Part A

- light microscope
- prepared slides of blood cells
- immersion oil

Part B

- microslide viewer
- microslides set 95, Human Blood

Section 1: Activity 5

Investigation: Cardiac Output and Blood Pressure

Part A

- a partner
- stethoscope
- sphygmomanometer
- clock or watch with a second hand

Part B

- a partner
- clock or watch with a second hand

Section 3: Activity 1

Investigation: The Structure and Function of the Neuron

- microslide viewer
- microslide set 221, Nerve and Muscle Action
- blank paper and pencil

Section 3: Activity 2

Investigation: The Structure and Function of the Mammalian Eye

- microslide viewer
- microslide set 69, The Central Nervous System
- blank paper and pencil

Section 3: Activity 3

- Precise Photographic Guide of the Sheep Brain

Investigation: Viewing the Spinal Cord

- microslide viewer
- microslide set 69, The Central Nervous System
- blank paper and pencil

Section 3: Activity 4

Investigation: Comparing Reflexes and Learned Neural Responses

- a partner
- plastic or wooden ruler (about 30 cm long)
- paper and pencil

Additional Resources

The ADLC Science 30 course wraps around the *Visions 3* textbook. A Teacher's Resource Manual is also available to teachers. This support includes suggestions, discussion initiations, social issues, cooperative learning ideas, evaluation ideas, and safety tips for labs. Each of the following resources can provide additional support and information for the teacher of Science 30.

Alberta Education. 1993. *Teacher Resource Manual.* Edmonton, Alberta. Department of Education, Curriculum Branch.

Campbell, Neil A. 1993. *Biology*. Third Edition. Redwood City, California: The Benjamin/Cummings Publishing Company, Inc.

Galbraith, Don. 1993. *Biology Directions*. Toronto, Ontario: John Wiley and Sons.

Ritter, Bob et al. 1993. *Nelson Biology*. Scarborough, Ontario: Nelson Canada.

Wallace, Robert A. et al. 1991. *Biology: The Science of Life*. Third Edition. New York, New York. Harper Collins Publishers Inc.

Mandatory Videos

The Human Body: Respiratory and Circulatory System, National Geographic, ACCESS Network, 1988.

Healthy Choices, Healthy Hearts, Alberta Heart and Stroke Foundation.

The Immune System: Your Magic Doctor, Barr Films, ACCESS Network, 1989.

The Human Body: Nervous System, National Geographic, ACCESS Network, 1988.

Optional Videos

The Senses, Introducing Biology, Marlin, 1978.

The Eye and Ear, Introducing Biology, Marlin, 1978.

Homeostasis: The Sea Within, T.V. Ontario, ACCESS Network, 1984, VC324402.

Other videos which may be used with this course are as follows:

- *Dissection & Anatomy of the Heart*, Nebraska Scientific, Northwest Scientific Supply, 1989.
- *Dissection & Anatomy of the Brain*, Nebraska Scientific, Northwest Scientific Supply, 1989.
- *Dissection & Anatomy of the Eye*, Nebraska Scientific, Northwest Scientific Supply, 1989.

Optional Laser Disk

The Living Textbook: Life Science (Side 2), Perceptix Inc., 1988. Available from Learning Resources Distributing Centre.

An additional laser disk that may be used with this module is

- *Atoms Anatomy: A Multimedia View of Human Systems, Level 1.* Distributed by Videodiscovery and Nystrom, Division of Herff Jones Inc., 1992. Telephone 1-(403)251-3904. Calgary, Alberta, Canada. T2V 4S7

Section 1: The Human Transport System

Key Concepts

- The circulatory system is made up of the heart, arteries, arterioles, veins, venules, and capillaries.
- The human heart consists of two separate pumps, the left side pumps oxygenated blood and the right side pumps deoxygenated blood.
- Arteries carry oxygenated blood while veins carry deoxygenated blood throughout the body.
- Arteries have thick walls to withstand and maintain high pressure while veins contain skeletal muscle and one-way valves.
- Blood is considered to be a tissue and is made up of specialized components.
- Chemical and electrical mechanisms regulate the cardiac output and blood pressure.
- High blood pressure is something that develops over a lifetime.

Teaching Suggestions

The emphasis in this section is on the circulatory system with respect to structure, function, and homestatic regulation. In Activity 1 students are to learn the basic parts of the heart and the path of blood circulation. In studying the heart it is important for students to view it as two separate pumps—the left side pumps oxygenated blood while the right side pumps deoxygenated blood. Students should also be able to establish relationships between the structure of the heart and its function. For example, the left ventricle is more muscular than the right since it has to initiate a force to pump blood throughout the entire body, whereas the right ventricle only has to initiate a force to pump to the lungs—a much shorter distance. For students to appreciate the circulatory system it is important for them to learn the path of blood circulation. This means that they should know the blood vessels associated with the heart, where they come from, and where they lead to. If students know the pathway of blood, they will understand the function of the circulatory system much better.

Activity 2 continues examining the structure of the circulatory system. It looks at arteries, veins, and capillaries. The focus here again is to relate structure to function. The arteries have thick walls and elastic tissue to withstand and maintain high arterial pressure. The veins contain skeletal muscle and one-way valves to keep the blood moving towards the heart. Emphasize to students that the functional difference between arteries and veins is due to the direction of blood flow rather than the oxygen content. The capillaries are thin walled and have a small diameter to facilitate exchange of materials.

In Activity 3 students are to learn the functions of the plasma and cellular components of human blood tissue. The emphasis here is for students to realize that blood is made up of specialized components which carry out specific functions to maintain equilibrium in the body. In addition, the role of blood as a tissue is studied. Students should understand the function associated with the digestive system, kidneys, liver, and lungs. Students should tie in the role of blood as a transport medium to facilitate the functions of these structures.

Activity 4 examines chemical (endocrine) and electrochemical (nervous) homeostatic regulatory mechanisms controlling cardiac output and blood pressure. Indicate to students that the hormonal and nervous systems play a role in communication throughout the body. Information is sent by chemicals or nerve impulses. With regards to hormonal regulation, students should understand the role of adrenaline and angiotensin II. It is also important for students to realize the significance of the kidney in controlling blood pressure. For nervous control, the role of the medulla oblongata and receptors (chemo and baro) should be emphasized. The investigation in this activity allows students to measure their blood pressure and pulse. With respect to using the stethoscope and sphygmomanometer for measuring blood pressure, it is important to caution the students in the use of this equipment. First of all, make sure to wash the ear plugs of the stethoscope to prevent ear infections. Second, inform students not to pump up the sphygmomanometer beyond 150 mm Hg. For students to measure blood pressure accurately, they will have to listen carefully. If a digital sphygmomanometer is available, it may be used to check the accuracy of the students' measurements. The last part of the activity takes a look at hypertension in terms of its causes and ways of prevention. It can be emphasized to students that high blood pressure usually develops over time and that lifestyle choices that they make now will affect their health later on in life.

Section 1: Assignment Answer Key (35 marks)

1. The following are the four chambers of the heart:

   - right atrium (deoxygenated)
   - right ventricle (deoxygenated)
   - left atrium (oxygenated)
   - left ventricle (oxygenated)

   (4 marks)

2. The following are the five major vessels:

   - superior vena cava—deoxygenated
   - inferior vena cava—deoxygenated
   - pulmonary veins—oxygenated
   - pulmonary artery—deoxygenated
   - aorta—oxygenated

   (5 marks)

3. This phenomenon is called the Bohr effect. **(1 mark)**

4. The general function of the valves in the heart is to prevent the backflow of blood. Specific names of heart valves include the bicuspid (mitral) valve and tricuspid valve which are located between the right atrium and ventricle. There is a semilunar valve between the right ventricle and the pulmonary artery and the left ventricle and the aorta. **(2 marks)**

5. Two possible structural characteristics and their related function are given for each type of blood vessel. Only one is required for each.

	Structural Characteristic	Related Function
Arteries	• elastic walls	• used to maintain blood pressure to keep blood moving in the proper direction
	• thick walls	• allows arteries to withstand a high pressure without being damaged
Veins	• skeletal muscle found on the outside of the vein	• contracts causing the blood in the vein to continue toward the heart
	• contain one-way valves	• keeps blood moving in one direction (towards the heart)
Capillaries	• thin walls	• allows materials to pass through the walls easily which facilitates exchange process between blood and tissues
	• small diameter (one red blood cell)	• slows the movement of blood which facilitates the exchange process

(6 marks; 1 mark for each structural characteristic, 1 mark for each related function)

6. a. The plasma contains proteins which play a role in blood clotting and protection against disease and infection (antibodies). **(1 mark)**

   b. The key function of the red blood cells (erythrocytes) is to transport oxygen to the cells of the body. **(1 mark)**

   c. The key function of the white blood cells (leukocytes) is to protect the body against infection and disease. **(1 mark)**

   d. The key function of the platelets is that they are involved in the clotting of blood. **(1 mark)**

7. a. The function of the blood in the digestive system is to absorb and transport the nutrients, which have been broken down by the digestive system, to the cells of the body. **(1 mark)**

   b. The function of the blood in the kidney is to transport metabolic waste materials along with other unwanted substances so that they may be excreted from the body. **(1 mark)**

c. The function of the blood in the liver is to transport materials to the liver so that the liver can process them appropriately. Examples include transport of glucose to the liver to allow storage in the form of glycogen or the breakdown of proteins to form the waste product urea. **(1 mark)**

d. The function of the blood in the lungs is to transport oxygen (inhaled) from the alveoli to the cells of the body and transport carbon dioxide from the cells to the alveoli (exhaled). **(1 mark)**

8. Nervous Control System—The receptors in the aorta and carotid arteries are stimulated and send nerve impulses to the medulla oblongata of the brain. Then the medulla interprets the situation and sends messages back to the heart and blood vessels. This results in an increase in the activity of the heart or results in constriction of the blood vessels which causes an increase in blood pressure. **(2 marks)**

   Hormonal Control—The action of the hormonal control system could include any two of the following:

   - Angiotensin II constricts blood vessels which raises blood pressure.
   - Angiotensin II acts on the kidney to cause an increase in blood volume which results in an increase in blood pressure.
   - Adrenaline causes an increased activity in the heart (greater force of contraction and a faster rate).

   (2 marks)

9. This statement refers to the idea that when a change occurs in the environment, the circulatory system can act to maintain an equilibrium (homeostasis/balance) in the body. Examples could include one of the following:

   - The flow of blood is increased during exercise to obtain more oxygen to satisfy the requirements of the cells.
   - More blood is sent to the digestive system to satisfy the requirements of the cells in this system after eating a meal.
   - A number of other relevant examples are possible.

   (2 marks for explanation, 1 mark for the example)

10. Any two of the following are acceptable:

    - Maintain a normal weight for your size (to prevent extra work for your circulatory system).
    - Maintain a diet of foods low in fat and cholesterol.
    - Do not smoke.
    - Reduce the stress in your life.
    - Reduce the intake of salt.

    (2 marks)

Section 2: Defence! Defence!

Key Concepts

- The skin and mucus are important aspects of the nonspecific line of defence.
- White blood cells are the second line of nonspecific defence.
- The immune system is a specific line of defence consisting of several specific purpose cells.
- Vaccines play an important role with respect to response of the immune system.

Teaching Suggestions

This section is concerned with the body's defence mechanisms. It focuses on the nonspecific and specific mechanisms of the body. The introductory activity emphasizes the nonspecific defence mechanisms. It examines the structural and functional role of the skin and mucous membranes. It should be noted that the mucous membranes line various tracts of the body but can be considered to lie exterior to the body if internal is defined as being in the bloodstream. The digestive tract has two openings and can be thought of as a tube running through the body. The respiratory tract has a single opening but materials present inside this tract can be considered exterior to the body. This activity also examines the role of the white blood cells as nonspecific phagocytes along with the events associated with the inflammatory response. It should be emphasized to students that the nonspecific defence mechanisms attack anything that is considered foreign, it does not distinguish one foreign agent from another. The nonspecific mechanisms represent the first and second lines of defence.

Activity 2 is where things can get a little complicated. Students are asked to learn the specific defence mechanisms, specifically the human immune system. They must gain an appreciation for the role of the cellular and noncellular components of the system such as macrophages, helper T cells, B cells, killer T cells, suppressor T cells, and memory T cells. The use of the concept maps in this activity can be used to improve the student's understanding of the immune system. Students should be able to distinguish between the terms *antigen* and *antibody*. One of the STS connections in this activity involves the workings of vaccines and the role they play with respect to the immune response. The understanding of vaccines will improve the student's understanding of the immune system. It should be emphasized to students that the specific mechanisms do distinguish one foreign agent from another and that these mechanisms provide immediate and long-term protection against disease and infection.

Section 2 Assignment Answer Key (30 marks)

1. Antigens are usually invaders of the body and are usually not produced by the body. Antibodies are produced in response to antigens and are usually produced by the body. **(2 marks)**

2. White blood cells produce antibodies, secrete destructive enzymes, suppress the immune response, and are capable of phagocytosis. **(2 marks)**

3. Cellular immunity requires the direct action of cells, whereas humoral immunity depends on proteins called antibodies. Cellular immunity also involves attacking invaders already in cells, whereas humoral immunity involves attacking free-floating pathogens. **(2 marks)**

4. a. Helper T cells aid other T cells and activate B cells. **(1 mark)**

   b. B cells produce antibodies. **(1 mark)**

   c. Killer (cytotoxic) T cells kill cells displaying the antigen. **(1 mark)**

   d. Suppressor T cells shut down the immune response once the invader has been destroyed. **(1 mark)**

5. The injection of a vaccine into the body will stimulate the production of antibodies specific to the antigen. The advantage of this is that you get protection from the disease without suffering the severe effects of it. **(2 marks)**

6. Individual B is suffering from a serious infection. This is because this individual's white blood cell count is much higher than normal. Since white blood cells are involved in fighting infections, it would seem likely that an individual with a high white blood cell count would have an infection of some sort. **(2 marks)**

7. Ways the skin is able to protect your body from infection include the following:

   - acts as a barrier to prevent penetration of viruses and bacteria
   - secretes acidic substances which maintain a skin pH between 3 and 5 creating conditions that would kill many microorganisms
   - secretes substances such as tears, saliva, and perspiration that contain the enzyme lysozyme that breaks down bacterial cell walls and kills the organisms

   (2 marks)

8. Mucous membranes are located in nasal sinuses, respiratory tract, digestive tract, and biliary or pancreatic systems. Removal of the mucous membranes would reduce the nonspecific defence mechanism. This would increase the chances of foreign agents invading the body resulting in an infection. **(2 marks)**

9. a. antibodies—specific **(1 mark)**
   b. phagocytic white blood cells—nonspecific **(1 mark)**
   c. skin—nonspecific **(1 mark)**
   d. lymphocytes—specific **(1 mark)**

10. Memory cells are important for protecting your body against a specific antigen in the future. Because your body has a memory of the invading antigen, it may react much faster and therefore increase the chances of destroying the antigen before it does any harm. Memory cells are produced in response to exposure to the specific antigen. **(2 marks for importance, 1 mark for how produced)**

11.

___e___ memory cells	___a___ antigen	___f___ suppressor cells
___c___ helper cells	___b___ nonspecific macrophage	___d___ killer (cytotoxic) cells

(3 marks)

12. Antibodies are protein substances whose function it is to tag and clump antigens so that they may be destroyed by other components of the immune system, like macrophages. Antibodies are produced by B lymphocytes. **(2 marks)**

Section 3: How Are Your Nerves?

Key Concepts

- The neuron is important in the transmission of nerve impulses.
- Sodium and potassium ions have an important role in the formation of action potentials which generate a nerve impulse.
- Receptors react to stimuli and create a nerve impulse.
- Examples of receptors are the eye and balance mechanisms in the ear.
- The nervous system consists of two major parts, the central nervous system, which processes information, and the peripheral nervous system, which carries information between the central nervous system and the rest of the body.
- The spinal cord is capable of processing and interpreting data.
- The brain is a very complex structure that integrates large amounts of information.
- The peripheral nervous system consists of the somatic and autonomic nervous systems.
- The autonomic nervous system is further subdivided in the sympathetic nervous system and parasympathetic nervous system.
- The sympathetic nervous system responds to emergencies and stress.
- The parasympathetic nervous system returns the body's activities back to normal.
- The reflex arc is an automatic response and does not involve the brain.

Teaching Suggestions

This section focuses on the nervous system and how it coordinates information within the body to maintain a state of equilibrium. In Activity 1 students will investigate the structure of the neuron. Students should be able to draw and label the parts of the neuron (the motor neuron is used in most texts). They should also know the functions associated with the parts. Students will learn about the formation of action potentials to generate a nerve impulse. This material can get complicated. It is suggested that you focus on the major concepts and not worry about the minute details. Students should be made aware of the key ions involved, charges at rest, what happens to the ions when an action potential is formed, how the charges change, and the formation of the nerve impulse. Students should also note what the all-or-none response is.

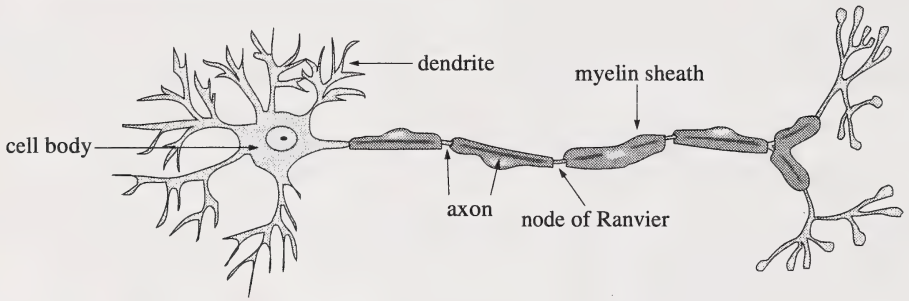
Activity 2 focuses on the structure and function of some of the receptors. It should be emphasized to students what receptors do—react to stimuli and create a nerve impulse. Students should be able to label the parts of the eye and know the functions associated with the parts. They should become familiar with the structures associated with the sense of balance. It should be noted that the hair cells are the balance receptors found in the utricle, saccuoe, and semicircular canals. You may wish to relate some experiences of your own where you have lost your sense of balance. The receptors of touch are also examined in this activity. Students should know what mechanorecptors are and where they are found.

Activity 3 looks at the organization of the nervous system. The chart in the text (Figure 2.13) serves as a good reference and may be used for the entire activity. Students must be able to distinguish between the CNS and the PNS on the basis of function. Emphasize to students that the spinal cord is capable of processing and interpreting data. They must be able to draw and label the major features of the brain. The brain is a complex structure which integrates information. Students should become familiar with the functions of the major parts of the brain but not worry about details. In discussion on the organization of the PNS, emphasize to students that there are two major divisions with the autonomic nervous system further subdivided into the sympathetic nervous system and parasympathetic nervous system. Students should know some of the specific effects of the sympathetic system.

The last activity puts the pieces together by examining the reflex arc and comparing it to a learned response. Students should tie together the role of the receptors, sensory neurons, central nervous system, motor neurons, and effectors. They all serve to coordinate information in the body to maintain a state of equilibrium. The distinction between a reflex arc and a learned response should also be noted.

Section 3 Assignment Answer Key (35 marks)

1. Students diagram should be similar to the following.



- dendrite – receives nerve impulses
- cell body – contains the nucleus that controls the functioning of the cell
- axon – extension of the cell body that transmits the nerve impulse away from the cell body
- myelin sheath – acts as an insulator by preventing the leakage of ions
  – action potentials do not occur in areas of the neuron that are surrounded by a myelin sheath
- node of Ranvier – area of the axon that is not surrounded by the myelin sheath
  – allows for action potentials to form and allows for quick conduction down the axon

(7 marks – 2 marks for labelled diagram and 1 marks for each function)

2. a. Movement of sodium ions into the cell cause a reversal in charge which is termed the action potential. **(2 marks)**

   b. A series of action potentials form a nerve impulse. **(1 mark)**

   c. The movement of potassium ions to the outside reverses the charge back to the original state. Na^+ ions are also removed by the Na^+/K^+ pump. **(1 mark)**

   d. The two key ions are sodium and potassium. **(2 marks)**

3. The neurotransmitters are stored in synaptic vesicles. The function of neurotransmitters is to carry information across the synapse to the postsynaptic membrane. **(3 marks; 1 mark for structure and 2 marks for function)**

4. Two types of photoreceptors are the rod and cone cells. These cells are located in the retina of the eye. **(3 marks)**

5. a. Hair cells located in your inner ear are the receptors. **(1 mark)**

   b. The hair cells are located in the semicircular canals, utricle, and saccule. **(1 mark)**

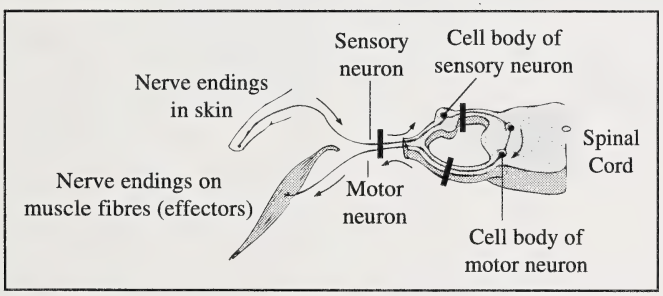
6. The central nervous system (CNS) processes and interprets information, whereas the peripheral nervous system (PNS) simply carries information back and forth. **(1 mark)**

7. Students should have three of the following responses.

   - spinal cord (a) – can process information and relays information to and from the brain
   - hypothalamus (b) – regulates body temperature and influences breathing and heart rate
     – is associated with pain, anger, sex drive, hunger, thirst, pleasure, and regulates many endocrine functions
   - pons (c) – serves as a relay station between the cerebellum and the medulla oblongata
   - cerebellum (d) – is the centre for muscle coordination and balance
   - corpus callosum (e) – allows brain hemispheres to communicate with each other
   - cerebrum or cerebral cortex (f) – controls higher level mental activities such as learning and memory
     – contains sensory centres and centres for controlling voluntary actions
   - medulla oblongata (g) – controls vital reflexes like heart rate, breathing rate
     – also controls sneezing and coughing

   (3 marks; $\frac{1}{2}$ mark for each name, $\frac{1}{2}$ mark for each funtion)

8.



Note: The three heavy lines indicate where injury could result in no information being transferred. **(3 marks for the diagram)**

A reflex arc consists of a sensory neuron and a motor neuron communicating through an interneuron. The information is received by the sensory neuron and sent directly to the motor neuron. A reflex arc would occur when there is a need to correct a potentially dangerous situation such as a burn. **(3 marks)**

9. a. The nerve impulses generated by the receptors travel to the brain in the central nervous system. Once the nerve impulses get to the brain they are processed and interpreted. **(2 marks)**

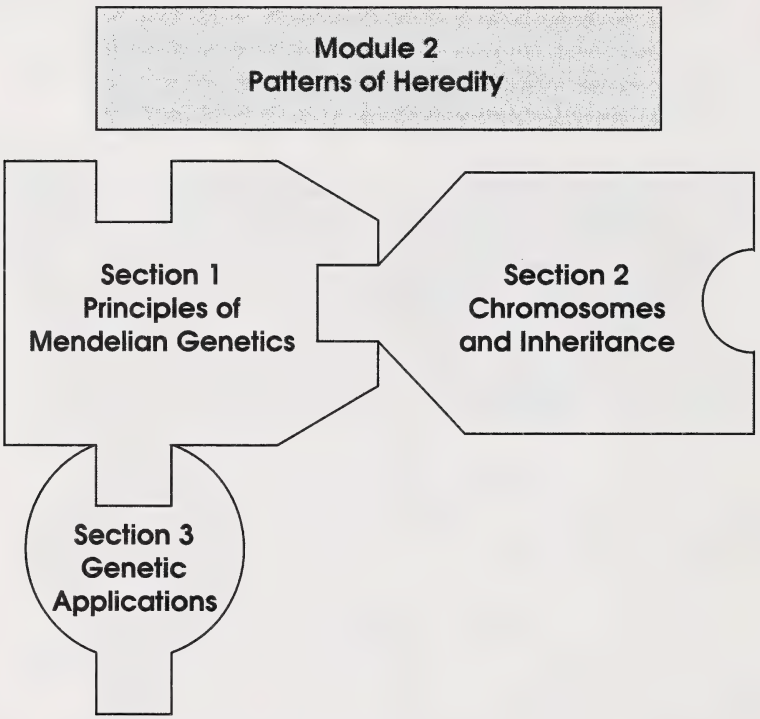
   b. This response differs from a reflex arc because the brain, rather than the spinal cord, does the processing and interpretation of information. **(1 mark)**

Module 2: Patterns of Heredity

Overview

In this module classical and molecular genetics are presented to the students. The principles of inheritance are examined, along with some common examples of genetic disorders, their detection, and possible solutions to the problems. First, Mendelian genetics and a few common applications of Mendel's laws are discussed. Then the biology of heredity (DNA) and cell division (mitosis and meiosis) are presented. A brief look at population genetics and certain genetic disorders and technologies completes this module.

It will be important for students to have a clear understanding of the science process skills. In this module careful consideration has been given to the use of investigations that enhance the development of these skills. The STS connections and attitudes to be encouraged can be reinforced effectively by a learning facilitator. This will prepare the student for the Science 30 Diploma Exam.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**30 marks**
Section 2 Assignment	**40 marks**
Section 3 Assignment	**30 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

Section 1: Activity 1

Investigation: Understanding Probabilities

- 4 coins
- paper and pencil
- ruler

Section 1: Enrichment

Investigation: Observing Inheritance Patterns

- fly culture vials containing 3 pairs of P generation *Drosophila*
- culture vials for matings and trays
- white card (8 cm × 13 cm) and #0 camel hair brush
- stereo dissecting microscope
- small jar of motor oil with lid
- paper and pencil and grease pencil

Section 2: Activity 1

Investigation: Simulating DNA Replication

- scissors
- coloured pencils
- transparent tape
- pages of symbols for DNA (In Appendix)
- blank sheet of paper

Section 2: Activity 2

Part A

Investigation: Chromosomes in Mitosis

- fresh onion with roots
- paper towels
- acetocarmine stain in dropping bottle
- 1 N HCl in dropping bottle
- slide and cover slip
- scalpel or razor blade
- bunsen burner and matches
- microscope
- forceps
- goggles

Part B

- microslide viewer
- microslide set 55, Plant Mitosis
- unlined paper and pencil

Section 2: Activity 3

Investigation: Meiosis in Ascaris

- microslide viewer
- microslide set 92, Meiosis
- unlined paper and pencil

Section 3: Activity 1

Investigation: Observing Single Trait Characteristics

- PTC papers (20)
- paper and pencil
- 10 subjects to survey (more if possible)

Section 3: Activity 2

Investigation: Human Karyotyping

- Individual A Karyotype
- human karyotype chart
- scissors
- blank paper and tape or glue-stick

Additional Resources

The *Visions 3* textbook is the one that the ADLC materials wrap around. The Teacher's Guide is designed to help teachers make the most of the textbook. This support includes suggestions on orientation and background, obtaining videos, initiating discussions, social issues, and evaluation ideas. Other helpful resources include the following:

Alberta Education. 1994. *Science 30 Resource Manual.* Edmonton, Alberta: Department of Education, Curriculum Branch.

Biggs, et al. 1991. *Biology: The Dynamics of Life*. Columbus, Ohio: Merrill Publishing Co.

Galbraith, Don. 1993. *Biology Directions*. Toronto, Ontario: John Wiley and Sons.

Hole, John W. Jr. 1990. *Human Anatomy and Physiology*. Dubuque, Iowa: Wm. C. Brown Publishers.

Monger, G. et al. 1986. *Revised Nuffield Advanced Science – Biology*. Essex, England: Longman Group Limited.

Oram, Raymond. 1986. *Biology: Living Systems*. Columbus, Ohio: Merrill Publishing Co.

Philips, W.D. et al. 1989. *A-Level Biology*. Toronto, Ontario: Oxford University Press.

Ritter, Bob et al. 1993. *Nelson Biology*. Scarborough, Ontario: Nelson Canada.

Wallace, Robert et al. 1991. *Biology: Science of Life*. New York, New York: Harper Collins Publishers, Inc.

Mandatory Videos

Section 2, Activity 1

Protein Synthesis: "Part 3, DNA Replication," ACCESS Network VC324603, 1988

Optional Videos

Section 2, Activity 1

Protein Synthesis: "The Molecule of Heredity," ACCESS Network, VC324602, 1988

Protein Synthesis: DNA Replication: The Repeating Formula, ACCESS Network, VC324603, 1988

Protein Synthesis: "RNA Synthesis: The Genetic Messenger," ACCESS Network, VC324604, 1988

Protein Synthesis: "Transfer RNA: The Genetic Messenger," ACCESS Network, VC324605, 1988

Section 2, Activity 3

Organic Evolution: Meiotic Mix, ACCESS Network

Other Videos

Biotechnology, ACCESS Network.

DNA: Laboratory of Life, National Geographic, 51048

Genetic Engineering and Protein Synthesis, Marlin Motion Pictures

Genetic Fingerprinting, RRUMC-3 Producer, Marlin Motion Pictures, ACCESS Network VC342801

Genetic Fix, Kinetic, ACCESS Network, VC303801, 1984

Delicate Balance: Human Health Through Biotechnology, Canadian Learning Corporation

The Geometry of Life: Exploring DNA and the Double Helix, New Vision Media

"The Genetic Code": *World of Chemistry* series, Magic Lantern

Barbara McClintock: Pioneer of Modern Genetics, available from Learning Resources Distributing Centre

Laser Videodisc

The Living Textbook Principles of Biology can be ordered from Perceptix Inc. (1-800-267-7788). It is also available from the Learning Resources Distributing Centre.

Note: Some of the suggested media may not be authorized by Alberta Education. Teachers should use their own discretion regarding the use of these resources in their classroom.

Section 1: Principles of Mendelian Genetics

Key Concepts

- True-breeding organisms will always produce descendants that are exactly the same as the parent organisms.
- Organisms have various traits which are passed on to descendants.
- When true-breeding organisms are crossed, certain traits appear in the first generation. These traits are called dominant traits.
- Recessive traits appear in the second generation in consistent patterns.
- Mendel's law of segregation states that each organism has two alleles for each gene and that each sex cell formed receives one allele for each gene.
- Mendel's law of independent assortment states that during sex cell formation the segregation of the alleles of one gene is independent of the segregation of the alleles of another gene.

Teaching Suggestions

The concepts in genetics are generally difficult ones for most students to comprehend. Prepare a bulletin board with pictures of Mendel and the Seven Contrasting Traits of Pea Plants he discovered. A model of a flower will help explain the important role it plays in reproduction. Also display pictures of cats with many different coat colours and label these pictures "multiple alleles." Use labelled popsicle sticks to help students understand segregation during gamete formation and the union of gametes producing offspring genotypes and phenotypes. The law of independent assortment is taught especially well with labelled and coloured popsicle sticks. Having eligible students donate blood so they can determine their ABO blood type really makes an impact on the class when studying multiple alleles. It is essential that students learn the vocabulary of genetics and feel comfortable with simple one and two trait crosses.

Section 1: Assignment Answer Key (30 marks)

1. D
2. B
3. B
4. D
5. A
6. D
7. C

All multiple choice are 1 mark each.

8. a.

	b	*b*
B	*Bb*	*Bb*
B	*Bb*	*Bb*

F_1: brown eyes $\frac{4}{4}$ **(1 mark)**

b.

	b	*b*
B	*Bb*	*Bb*
b	*bb*	*bb*

F_1: brown hair $\frac{2}{4}$

blonde hair $\frac{2}{4}$ **(1 mark)**

c.

	C	*c*
C	*CC*	*Cc*
c	*Cc*	*cc*

F_1: curly hair $\frac{3}{4}$

straight hair $\frac{1}{4}$ **(1 mark)**

d.

	L	*l*
L	*LL*	*Ll*
L	*LL*	*Ll*

F_1: long eyelashes $\frac{4}{4}$ **(1 mark)**

e.

	i	*i*
I^A	I^Ai	I^Ai
I^B	I^Bi	I^Bi

F_1: type A $\frac{2}{4}$

type B $\frac{2}{4}$ **(1 mark)**

9. P_1 : tall × short Phenotype F_1 : $TT \times tt$

TT tt Genotype

	t	t
T	Tt	Tt
T	Tt	Tt

Phenotype: All are tall. **(1 mark)**

F_2 : $Tt \times Tt$

	T	t
T	TT	Tt
t	Tt	tt

Phenotypic Ratio: $\frac{3}{4}$ tall, $\frac{1}{4}$ short **(2 marks)**

10. You would cross the straight-winged fly with a curly-winged fly. If all the offspring produced are straight-winged, then the straight-winged fly is homozygous. If some of the offspring show curly wings, then the fly must be heterozygous. **(3 marks)**

11. a. Juan's genotype is X^cY. The allele reperesenting colour blindness is *c* and it is on the X chromosome. **(1 mark)**

b. Hanna's genotype is X^CX^c. She is a carrier, phenotypically normal, but recipient of the recessive allele from her father. **(1 mark)**

c. Hanna must be a carrier for hemophilia and has transmitted the allele to her son. Her brother must have received the recessive allele from his mother also. **(1 mark)**

d.

Hanna / Juan	X^C	X^c
X^c	X^CX^c	X^cX^c
y	X^CY	X^cY

Hanna / Juan	X^H	X^h
X^H	X^HX^H	X^HX^h
Y	X^HY	X^hY

Offspring: $\frac{1}{2}$ of the daughters will be colour blind. Punnett square shows one daughter with recessive allele for colour X^cX^c. **(1 mark)**

$\frac{0}{2}$ of the daughters will be hemophiliac. Punnett square shows no daughters with a double recessive allele for hemophilia. However, $\frac{1}{2}$ of Hanna's daughters will be carriers of hemophilia. **(1 mark)**

12. All offspring receive a recessive allele from one of the parents. The genotype of the other parent will, therefore, determine the phenotype of the offspring as shown:

If P_1 : $TT \times tt$, then F_1 : 100% Tt – all tall plants.

If P_1 : $Tt \times tt$, then F_1 : $\frac{2}{4}Tt$ – 50% tall plants and $\frac{2}{4}tt$ – 50% short plants.

If all resulting crosses are tall plants when the test cross is done, then you would know that the parent was TT. If some of the resulting crosses are tall and some are short, then you know the parent was Tt. **(2 marks)**

13. Female Orphan $\rightarrow I^A I^B$ One allele from each parent

    Parents $\rightarrow$ Father I^A ?, Mother I^B ?

    a. The mother cannot have type A because daughter must receive I^B from mother. **(1 mark)**

    b. The mother can have type B and donate I^B to daughter. **(1 mark)**

    c. The mother can have type AB and donate I^B to daughter. **(1 mark)**

    d. The mother cannot have type O because daughter must receive I^B from mother. **(1 mark)**

    e. The mother with type B could be homozygous $I^B I^B$, but a mother with type AB is definitely heterozygous $I^A I^B$. Therefore, the adoptee's mother is the type B mother (b). **(1 mark)**

Section 2: Chromosomes and Inheritance

Key Concepts

- Chromosomes are strands of DNA present in each cell.
- The genetic code is stored in the DNA sequence of bases in the chromosomes.
- Cell division involves DNA replication and protein synthesis.
- Mitosis is the process of cell division used when a cell divides to form two identical daughter cells.
- Mitosis occurs in four distinct phases along with an interphase or time between phases.
- Meiosis is the process of cell division used when cells divide to form gametes or sex cells.
- Mitosis results in exact duplication of cells whereas meiosis results in production of cells containing half the usual chromosome number and allows for variation in the chromosome material.

Teaching Suggestions

The concepts in this section may be best understood as students compare growth of an organism to the production of a new organism. Growth implies copying the original just like a photocopier makes exact multiple copies to create a larger stack. A new organism is the product of a special cell division that allows for genetic variation and a reduced chromosome number in the gametes produced. Using models of cells at various stages of division will help students conceptualize mitosis and meiosis. Pipe cleaners could be used to represent chromosomes, so students can simulate what happens to genetic material during cell division. Also snap-together beads can be used to illustrate crossing over. A model of DNA helps students understand how genetic material is organized into codons, genes, and chromosomes. The blueprint analogy seems to be a practical way for students to conceptualize how genetic information can act as a guide to allow cells and organisms to express their physical traits.

Section 2: Assignment Answer Key (40 marks)

1. D 2. B 3. B 4. D

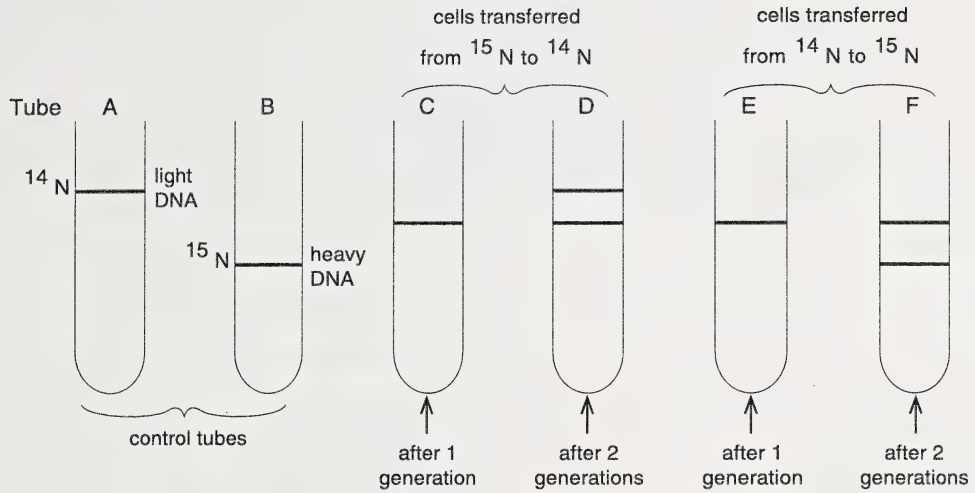
All multiple choice are 1 mark each.

5. The student's response should include a discussion similar to the following.

   The importance of control Tube A is that it shows the weight of the "light" DNA which is essential as a benchmark for further comparisons. **(1 mark)**

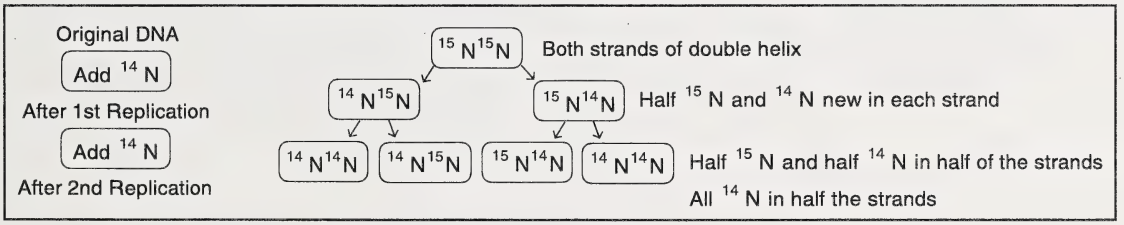
   The importance of control Tube B shows the weight of the "heavy" DNA. When centrifuged, these bacteria will be lower in the tube and can be used as a second reference point. **(1 mark)**

   The following diagram shows the predicted level of the bacteria culture in each of the test tubes labelled C, D, E and F. **(1 mark)**



Tube C shows an intermediate band because one half of the new double helix will be old ^{15}N and the other half will be new ^{14}N.
(1 mark)

Tube D shows an intermediate band and a light band because the second replication will use ^{14}N only as shown.
Note: Tube D includes the medium band from Tube C. **(1 mark)**



Note: Half ^{15}N and half ^{14}N results in the medium band. All ^{14}N results in the light band.

Tube E will show an intermediate band because one half of the new double helix will be old ^{14}N and one half will be new ^{15}N.
(1 mark)

Tube F will show an intermediate band and a heavy band because the second replication will use ^{15}N only. **(1 mark)**

Technology (Any 2, 2 marks)

The technology that could be used today could involve any of the following. Centrifuging can be used when the cultures are spun at high speeds and separated by weight as shown by Meselson and Stahl.

Stains could be used with a light microscope to observe old and new strands in double helix.

Computer imaging could be used to show the replication process.
(2 marks for communication)

6. a. The complementary bases in the DNA would be AGTTAT. **(3 marks; $\frac{1}{2}$ mark each)**

   b. Since each codon is 3 bases and there are now 24 bases, there must be 8 codons. **(1 mark)**

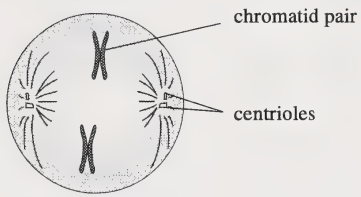
   c.

mRNA	AUG	CCG	AUC	UCA	AUA	UGC	GGC	AAC
Protein (amino acid chain)	Methionine	Proline	Isoleucine	Serine	Isoleucine	Cysteine	Glycine	Aspargine

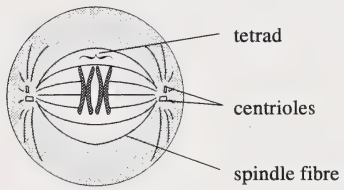
   (4 marks)

7. Your diagrams should be similar to the following. Give 1 mark for each diagram and 1 mark for accurate labels on each diagram.

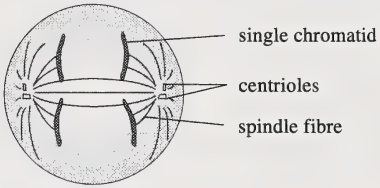
   a. Prophase of Mitosis



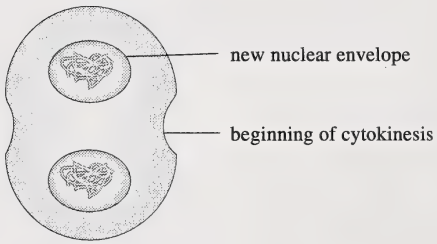
   b. Metaphase of Meiosis I



   c. Anaphase of Meiosis II



   d. Telophase of Mitosis



8. A cell that divides its nucleus, but not its cytoplasm, would have two nuclei in the same cell. **(1 mark)**

9. a. A gene is a functional section of the DNA that codes for a specific trait. A chromosome is a long string of genes linked together. It is made of DNA. **(2 marks)**

   b. Gap 1 is the portion of the cell cycle where DNA transcription, RNA translation, and protein synthesis allow the cell to grow and specialize in its function. Gap 2 is the portion of the cell cycle where the preparations for cell division occur. **(2 marks)**

   c. Mitosis is simple cell division where the parent cell produces two identical offspring cells. Meiosis is reductive cell division (i.e., $2N \rightarrow N$), where the parent cell produces gametes that have single chromosomes instead of homologous pairs. **(2 marks)**

   d. Prophase I is where synopsis occurs and crossing over may occur between homologous chromosome pairs. This does **not** occur in prophase II which precedes chromatid pair alignment in metaphase. **(2 marks)**

Section 3: Genetic Applications

Key Concepts

- The Hardy-Weinberg principle is a mathematical representation of Mendel's first law.
- The equation for the Hardy-Weinberg principle allows for the calculation of frequencies and numbers of a population of homozygous dominant allele genotypes, homozygous recessive allele genotypes, and carrier genotypes.
- Nondisjunction is an error in chromosome segregation resulting in an abnormal number of chromosomes in the gametes which in turn results in abnormal offspring.
- Mutations are errors that occur in DNA replication involving a change in base sequences.
- Mutations are the result of interference in the DNA replication process by various chemicals called mutagens.
- The selective transfer of genes from one organism to another is called genetic engineering.
- Genetic engineering can be applied to humans to correct certain disorders.
- There is also a potential to use genetic engineering to alter human sex cells or embryos resulting in controversial moral issues for society.

Teaching Suggestions

A great way to introduce the concept of population genetics is to check for a trait like the presence of ear lobes with the class. This illustrates differences in the population. The concept of genetic abnormalities can be shown by gathering together the bar codes from various product wrappers. Each bar code can represent a gene. You can create a chromosome by linking a number of codes together. Exchanging bar codes or cutting them into smaller pieces and rearranging them will illustrate to the students exactly what happens when mutations occur. You may wish to invite a geneticist or biochemical engineer to speak to the students about the current research and applications of technology being used in the world today. Perhaps your class will have a student whose family has first-hand experience in dealing with some of the more common examples of errors in genetic inheritance like Down syndrome, skin disorders, or hemophilia. A presentation would make these conditions more meaningful and understandable. A field trip to an agricultural site where genetic engineering is used to improve the quality and quantity of food production would also be valuable.

Section 3: Assignment Answer Key (30 marks)

1. A 2. A 3. B 4. A 5. B All multiple choice are 1 mark each.

6. The student's response should include a discussion of the following:

Point Mutations

- Any alteration to a single base pair, a codon, or a gene will change the sequences in the genetic code. **(1 mark)**
- Causes may include radiation (ultraviolet light, X-rays, or nuclear), chemicals, or inaccuracies in DNA replication or transcription. **(1 mark)**
- Specific examples will vary, but may include cancers, AIDS or other viral infections, sickle cell anemia, phenylketonuria, or hemophilia. **(1 mark)**

Chromosome Mutations

- Any alteration to a chromosome adds or loses genes. Nondisjunction is a common type of mutation where there is not the correct number of chromosomes. **(1 mark)**
- Causes may include radiotherapy treatment, environmental factors (mutagens), and age of person. **(1 mark)**
- Specific examples may vary, but should include any of the trisomies (18, 21, or sex chromosomes XXY, XYY). **(1 mark)**

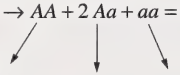
Technology (Any 2, 2 marks)

- Amniocentesis is a diagnostic technology used to discover human karyotypes.
- Fetoscopy and ultrasonography are also diagnostic technologies used to discover visible abnormalities.
- Cloning is an engineering technology used to manipulate reproductive processes.
- Recombinant DNA utilizes bacteria to create corrections to genetic problems.
- Gene therapy allows a healthy gene to replace a defective one in the treatment of disorders.

(2 marks for communication)

7. a. $p+q=1 \rightarrow p^2+2pq+q^2=1$ (Hardy-Weinberg principle)

$A+a=1 \rightarrow AA+2Aa+aa=1$ (Mendel's laws)



Dominant Carriers Recessive

First a value for q is found. Then the frequency of carriers is found by evaluation of $2pq$.

$$q^2=\frac{1}{10\,000}=0.0001,$$

$$q=0.01$$

$$\therefore p=1-0.01$$

$$=0.99$$

$$2pq=2\times0.99\times0.01 \quad \textbf{(1 mark)}$$

$$=0.0198$$

The frequency of carriers is 0.0198. **(1 mark)**

b. If $q=0.3$ and q^2 represents the diseased individuals,

Then $q^2=0.3^2=0.09\times1000$ **(1 mark)**

$=90$

There would be 90 diseased individuals. **(1 mark)**

c. The function of the Hardy-Weinberg principle is to predict what gene frequencies should be if there is no change to the gene pool. It is like a control in an experiment. If changes in gene frequencies do occur over time, then you know the gene pool of the population is changing. **(1 mark)**

8. a. Karyotyping is a technology used to determine the chromosome complement in the nucleus of a cell. In this way, abnormalities can be discovered. **(1 mark)**

b. The Human Genome Project is an effort to map the positions of all the genes in all the chromosomes in a human cell. This will advance the research in genetic engineering that may eradicate mutations. **(1 mark)**

c. Restriction enzymes serve to cut up DNA into genes so these genes can be spliced into other DNA and introduced into bacterial chromosomes. **(1 mark)**

d. These small loops of DNA can accept foreign genes producing recombinant DNA. Inserted back into a bacterium, these new genes can function normally in producing specialized proteins for activity within organisms. **(1 mark)**

e. Mutagens are agents that cause mutations. They may be chemicals, radiation, or viruses. **(1 mark)**

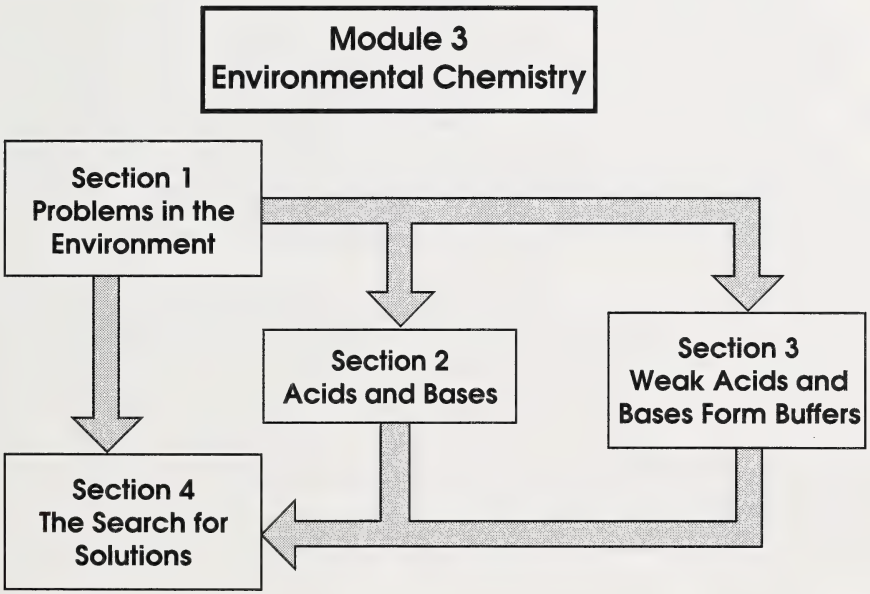
9. This individual has forty-six chromosomes, which is a normal number but the makeup of chromosomes is abnormal. There are three number 18 chromosomes, which would cause Edward syndrome, and only a single X chromosome, which would cause Turner syndrome. The individual would be female having one X chromosome and no Y chromosome. Both Edward and Turner syndrome result from nondisjunction. Either the sperm or egg carried two number 18 chromosomes and/or lacked a sex chromosome prior to fertilization. **(5 marks)**

Module 3: Environmental Chemistry

Overview

This module teaches students the chemistry of acids, bases, and buffers from a context of environmental chemistry. The principles of acids, bases, and buffers are dealt with and then applied to analysing environmental problems involving pollution. The organization of the module is to present some environmental problems first, lead into acids, bases, and buffers, and then finish with some solutions that are in place now.

It will be important for students to have a clear understanding of these science process skills. In this module careful consideration has been given to the use of investigations that enhance the development of these skills. The STS connections and attitudes can be reinforced by a learning facilitator.



Evaluation

The evaluation of this module will be based on four assignments:

Section 1 Assignment	**20 marks**
Section 2 Assignment	**30 marks**
Section 3 Assignment	**30 marks**
Section 4 Assignment	**20 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

The following is a list of materials and equipment necessary for an individual to complete the investigations and activities in Module 3. Adjust the amount of equipment if more than one individual is involved.

Section 1: Activity 1

Investigation: What Is too Much Pollution?

- 8 glasses (preferably the same)
- 1 tbsp (tablespoon) of salt
- 1 tbsp (tablespoon) of sugar
- ruler
- grease pencil, felt pen, or tape

Section 2: Activity 4

Investigation: Titrating to Find Concentration

Part A

- 0.10 mol/L standardized sodium hydroxide solution, $NaOH_{(aq)}$ (30 mL)
- hydrochloric acid of unknown concentration (30 mL)
- phenolphthalein or bromothymol blue indicator solution (5 mL)
- buret and clamp with stand
- 25 mL pipet or 10 mL pipet
- 100 mL beaker
- eyedropper

Part B

In addition to the materials from Part A students will need the following:

- pH meter and accessories
- graph paper, pencil

Part C

- data in Observations section of the Student Module booklet
- graph paper
- pencil

Section 3: Activity 3

Investigation: Investigating the Buffering Capacity of the Environment

- water sample (from dugout or lake or prepared from soil sample)
- distilled water
- filter paper and funnel
- 100 mL beaker
- 0.100 mol/L $HCl_{(aq)}$ (10 mL)
- 0.100 mol/L $NaOH_{(aq)}$ (10 mL)
- methyl orange indicator (5 mL)
- pH indicator paper (1–14)
- eyedropper

Mandatory Videos

Section 4, Activity 1

Planet Under Pressure: Acid Assault, T.V. Ontario, ACCESS Network, 1991, available from Learning Resources Distributing Centre.

Optional Videos

Section 4, Activity 3

Planet Under Pressure: Ozone, T.V. Ontario, ACCESS Network, 1991.

Section 4, Extra Help

Acid Rain: North American Challenge, ACCESS Network.

Section 1: Problems In the Environment

Key Concepts

- Pollution depends on quantity.
- Lifestyle has created a number of pollution problems.
- One pollutant has caused a major problem in the atmosphere.
- Ozone is beneficial in the atmosphere but a pollutant on the ground.
- Smog is the result of various chemicals and particular weather conditions.
- Acid rain is a major pollution problem involving international boundaries.

Teaching Suggestions

This section is mostly informational, so it is recommended that all the students do the opening lab. It's easy and can be fun. One surprise that students find is that the iodine in the salt is detectable before the salt taste.

All these issues are in the media from time to time so this unit should help clarify some of the things the students hear.

Section 1: Assignment Answer Key (20 marks)

1. Substances aren't pollution if they are in the right places. For example, gasoline in the tank is not pollution but gasoline spilled on the ground is pollution. **(2 marks)**

2. There is no control over natural contaminants. The Earth has coped with it for billions of years. It's what people do that can be controlled. **(2 marks)**

3. A beneficial effect of herbicides, pesticides, and chemical fertilizers is that they increase yields of agricultural and recreational products in the short term. **(2 marks)**

   The long-term harmful effects of herbicides, pesticides, and chemical fertilizers include harm done to beneficial species, an increase in resistance of species, loss of topsoil due to increased erosion, loss of nutrients in the soils. **(2 marks)**

4. Chlorine atoms destroy the ozone by catalysis. The equations are as follows.

   $$Cl_{(g)} + O_{3(g)} \rightarrow ClO_{(g)} + O_{2(g)}$$
   $$ClO_{(g)} + O_{(g)} \rightarrow Cl_{(g)} + O_{2(g)}$$

   The chlorine atom removes an oxygen atom from the ozone (O_3), destroying the ozone. The chlorine atom now is combined with an oxygen atom. However, it does not remain this way. In time the $ClO_{(g)}$ molecule combines with another free oxygen atom. The chlorine releases its oxygen atom to form a free chlorine atom and an oxygen gas molecule. The free chlorine is now capable of destroying another ozone molecule through the same process. The chlorine atoms stay in the stratosphere for years and can repeat this process thousands of times. **(4 marks)**

   Note: The word explanation is sufficient for 4 marks or marks may be awarded for a combination of equations and word explanation.

5. The cars produce NO_x in the early morning but ozone and other smog ingredients, being secondary pollutants, take time and the effect of sunlight to form. The smog peak occurs when these secondary pollutants have formed There is no peak after the evening rush hour because there isn't enough sunlight to produce the secondary pollutants. **(2 marks)**

6. The elimination of sulphur dioxide and nitrogen oxides could reduce acid deposition. **(2 marks)**

7. Both emissions react with water to form acids. Students require only one of the following explanations and pairs of equations for four marks.

   In the case of sulphur dioxide, first sulphurous acid is formed when sulphur dioxide and water combine. Then sulphurous acid and water combine to form sulphuric acid. The equations for the formation of these two acids are as follows.

   $$SO_{2(g)} + H_2O_{(1)} \rightarrow H_2SO_{3(aq)}$$ sulphurous acid
   $$H_2SO_{3(aq)} + H_2O_{(1)} \rightarrow H_2SO_{4(aq)}$$ sulphuric acid

In the case of nitrogen monoxide, first nitrous acid is formed from the combination of nitrogen oxide and water. Next nitric acid is formed when nitrous acid and water combine. The equations are as follows.

$$NO_{(g)} + H_2O_{(1)} \rightarrow HNO_{2(aq)} \quad \text{nitrous acid}$$
$$HNO_{2(aq)} + H_2O_{(1)} \rightarrow HNO_{3(aq)} \quad \text{nitrous acid}$$

Note: Give 2 marks for the explanation and 1 mark for each correct equation. **(4 marks)**

Section 2: Acids and Bases

Key Concepts

- Acids and bases exhibit certain properties when dissolved in water.
- There are several ways to define acids and bases.
- Strength and concentration are different measures of acids and bases.
- Acids and bases are among the most widely used chemicals.
- Strong acids and bases dissociate completely while weak acids and bases dissociate only partly.
- pH is a measure of the hydronium ion concentration of acids and bases.
- pH is calculated by taking the negative log of the hydronium ion concentration.
- pH can be measured using pH paper, indicator solutions, or a pH meter.
- Titration can be used to determine the concentration of an acid or a base.

Teaching Suggestions

The emphasis here is on strong acids and bases. Both the Arrhenius and Brønsted-Lowry theories are presented, but the Brønsted-Lowry theory is used more later on.

Concentration and pH, being mathematical, have their usual problems for students. Any extra practice they can get is helpful.

Section 2: Assignment Answer Key (30 marks)

1. $HCl_{(aq)}$ ionizes into ions as follows:

   $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

   The $H^+_{(aq)}$ shows that it is an Arrhenius acid. **(2 marks)**

   $HCl_{(aq)} + H_2O_{(1)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

   The $HCl_{(aq)}$ donates a proton to the water. This shows $HCl_{(aq)}$ is a Brønsted-Lowry acid as well. **(2 marks)**

2. $NH_{3(aq)} + H_2O_{(1)} \rightarrow NH^+_{4(aq)} + OH^-_{(aq)}$

   The ammonia has accepted a proton from the water, so it's a Brønsted-Lowry base. Ammonia has no OH^- ions, so it isn't an Arrhenius base. **(2 marks)**

3. One risk of acids and bases is that they are corrosive and must always be handled, transported, and stored with extreme caution. **(1 mark)**

   A benefit of acids and bases is that they can be used to make a large variety of items like fertilizers, soaps, paints, and so on. **(1 mark)**

4. a. $\left[H_3O^+_{(aq)}\right] = \text{antilog}(-\text{pH})$

$= \text{antilog}(-1.0)$

$= 0.1 \text{ mol/L}$

(1 mark)

b. The pH after each dilution can be calculated as follows.

1st Dilution: $\left[H_3O^+_{(aq)}\right] = \frac{1}{10}(0.1 \text{ mol/L})$

$= 0.01 \text{ mol/L}$

and $\text{pH} = -\log\left[H_3O^+_{(aq)}\right]$

$= -\log(0.01)$

$= 2.0$

2nd Dilution: $\left[H_3O^+_{(aq)}\right] = \frac{1}{10}(0.01 \text{ mol/L})$

$= 0.001 \text{ mol/L}$

and $\text{pH} = -\log\left[H_3O^+_{(aq)}\right]$

$= -\log(0.001)$

$= 3.0$

The pH after the first dilution is 2.0 and 3.0 after the second dilution. **(4 marks)**

c. As the concentration of $\left[H_3O^+_{(aq)}\right]$ changes by a factor of 10 times, the pH changes by 1. **(1 mark)**

5. First find the $\left[H_3O^+_{(aq)}\right]$ as follows

$\left[H_3O^+_{(aq)}\right] \times \left[OH^-_{(aq)}\right] = 1.0 \times 10^{-14} \text{ mol}^2/\text{L}^2.$

$\left[H_3O^+_{(aq)}\right] = \frac{1 \times 10^{-14} \text{ mol}^2/\text{L}^2}{\left[OH^-\right]}$

$= \frac{1 \times 10^{-14} \text{ mol}^{\cancel{2}}/\text{L}^{\cancel{2}}}{8.0 \times 10^{-7} \cancel{\text{mol/L}}}$

$= 1.25 \times 10^{-8} \text{ mol/L}$

Then $\text{pH} = -\log\left[H_3O^+_{(aq)}\right]$

$= -\log\left(1.25 \times 10^{-8}\right)$

$= 7.903$

$= 7.90$ (2 significant digits)

The pH of a solution which has a $\left[OH^-_{(aq)}\right]$ of 8.0×10^{-7} mol/L is 7.90. **(3 marks)**

6. a. Step 1: Measure 25 mL of $KOH_{(aq)}$ into a beaker using a 25 mL volumetric pipette.

Step 2: Fill the buret with the 0.050 mol/L standard $HCl_{(aq)}$.

Step 3: Read and record the initial buret volume.

Step 4: Add two or three drops of indicator (phenolphthalein or bromothymol blue) to the $KOH_{(aq)}$ solution.

Step 5: Titrate with the $HCl_{(aq)}$ solution until the indicator colour makes a permanent change.

Step 6: Read and record the final buret volume.

Step 7: Repeat Step 1 to Step 6 two more times.

(3 marks)

b. There would be a change from pink to colourless if phenolphthalein is used or blue to yellow if bromothymol blue is used. **(1 mark)**

c. For the titrant:

Average Volume $= 36.9$ mL **(1 mark)**

$= 0.0369$ L

Find the amount of $HCl_{(aq)}$ in moles.

$n = CV$ **(1 mark)**

$= 0.050 \frac{mol}{\cancel{L}} \times 0.0369 \cancel{L}$

$= 1.845 \times 10^{-3}$ mol

Reaction: $HCl_{(aq)} + KOH_{(aq)} \rightarrow HOH_{(l)} + KCl_{(aq)}$

titrant unknown

The mole ratios are all 1:1 in the reaction so there is also 1.845×10^{-3} mol of $KOH_{(aq)}$. **(1 mark)**

Find the concentration of $KOH_{(aq)}$.

$C = \frac{n}{V}$

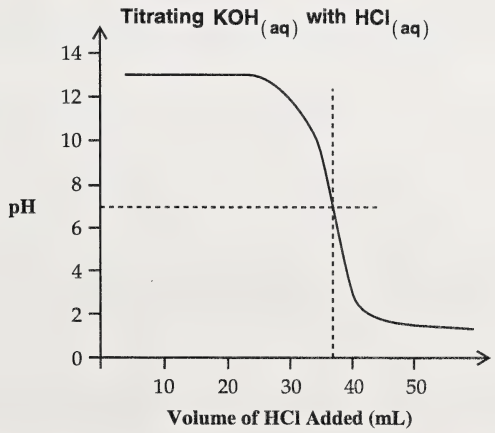
$= \frac{1.845 \times 10^{-3} \text{ mol}}{0.025 \text{ L}}$

$= 7.38 \times 10^{-2}$ mol/L

$= 7.4 \times 10^{-2}$ mol/L (2 significant digits)

The concentration of the potassium hydroxide is 7.4×10^{-2} mol / L. **(2 marks)**

7. This is the shape of the curve. Point A should be close to pH 7 and a volume of acid added of 37 mL.



(4 marks)

Section 3: Weak Acids and Bases Form Buffers

Key Concepts

- Buffers are chemicals that can prevent a sudden change in pH when small amounts of strong acids or bases are added to the solution.
- Weak acids or weak bases can be used as buffers.
- Body systems make use of the buffering action of weak acids and bases.
- Certain soils and rocks provide buffering action for the environment.

Teaching Suggestions

This is probably the hardest section for a student to learn. Percent dissociation of weak acids is mathematical and the concept of a buffer is hard to grasp.

The textbook explains buffering action differently than this module does. Both methods can explain the idea but the way chosen here is a more "modern" way to look at it. The students' ideas of dynamic equilibrium will be tested as they try to envision how buffering works.

The lab with local water can be done at home or school.

Section 3: Assignment Answer Key (30 marks)

1. a. False. Weak acids are acids that ionize much less than 100%.

   b. True

   c. False. It comes from the acid ionization and from dissolved salts.

   d. True

   e. False. Each buffer system works at its own optimum pH level. Different buffers have different pHs.
   (8 marks; 1 mark for each true statement and 2 marks for each false statement.)

2. a. The strong acid increases the $\left[H_3O^+_{(aq)}\right]$. The acetate ions combine with the $\left[H_3O^+_{(aq)}\right]$ producing acetic acid. This reduces the $\left[H_3O^+_{(aq)}\right]$ so the pH remains relatively steady as the acetic acid does not increase the $\left[H_3O^+_{(aq)}\right]$ significantly. **(3 marks)**

   The equation for the buffer system looks like the following.

   $$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$$ **(1 mark)**

   b. The acetic acid does not increase the pH significantly because it does not ionize very much. **(1 mark)**

   c. The buffering stops when the acetate ions are used up by the strong acid and the $\left[H_3O^+_{(aq)}\right]$ increases rapidly. At this point the pH decreases rapidly. **(3 marks)**

3. Find the hydronium ion concentration:

$$\left[H_3O^+_{(aq)}\right] = \text{antilog}(-\text{pH})$$
$$= \text{antilog}(-2.2)$$
$$= 6.31\times10^{-3}\ \text{mol/L}$$

The percent dissociation is:

$$\frac{\left[H_3O^+_{(aq)}\right]}{[\text{acid}]}\times100 = \frac{6.31\times10^{-3}\ \cancel{\text{mol/L}}}{0.100\ \cancel{\text{mol/L}}}\times100$$
$$= 6.31\%$$
$$= 6\%\ (1\ \text{significant digit})$$

The percent dissociation of the acid is 6%. **(4 marks)**

4. The chemicals found in dissolved salts are weak bases and provide a buffer for the aquarium water. The fish are protected from sudden pH shifts. **(2 marks)**

5. The mixture of indicators would work between pH 1.4 and pH 4.6. It would probably be orange below pH 1.4, yellow from pH 2.8 to pH 3.0, and green above pH 4.6. **(2 marks)**

6. Your body regulates the amount of carbonic acid in your blood. It does this through $CO_{2(g)}$ exchange in your lungs and breathing rate. Sensors in the medulla detect the pH and regulate the breathing rate accordingly. **(2 marks)**

7. Alberta bedrock is mostly carbonate so there is an enormous source of basic ions to neutralize acids. Alberta soil conditions are such that the soils will neutralize acids as well. **(2 marks)**

8. The antacid is simply a weak base that neutralizes some of the acid in the stomach. No, this is not an example of buffering. **(2 marks)**

Section 4: The Search for Solutions

Key Concepts

- A pollutant must be identified and its concentration determined if it is to be eliminated.
- Pollution can be reduced by cleaning up the pollutants.
- Pollution can be reduced by eliminating the source of the pollution.

Teaching Suggestions

This section is written as a concluding segment. Methods of detection of pollution are shown in an informational way. If time permits, it might be worthwhile to try an experiment like the one in Activity 1. The text, *Bottle Biology*, University of Wisconsin, has good ideas for this.

The idea of the technological fix is explored next. An attempt is made to get students to see past this technique and identify that lifestyle changes are required to reduce pollution sufficiently.

Section 4: Assignment Answer Key (20 marks)

1. Alberta has less of a problem with acid rain because it does not have as much pollution produced by industry as Eastern Canada. In addition, Eastern Canada has some acid-rain producing pollutants blown in from the heavy industrial areas of the Eastern United States. Weather conditions in Alberta tend to blow the pollution produced in Alberta into Saskatchewan and the Northwest Territories. In addition Alberta has a much higher buffering capacity in terms of its rock type and soils than that of Eastern Canada. **(4 marks)**

2. Before you can solve a problem you have to know what that problem is. Identifying pollutants and their consequences through scanning satellites might give the political and economic will to solve these problems. **(2 marks)**

3. • People usually take the path of least resistance. It's easier to let someone else solve your problems.
• Economic situations support those industries that create the pollution, (and those industries exist to give people what they want).
(2 marks)

4. a. $\left[H_3O^+_{(aq)}\right] = \text{antilog}(-\text{pH})$ $\longrightarrow$ $n = CV$

$= \text{antilog}(-5.00)$ $= 1.0\times10^{-5}\ \frac{\text{mol}}{\text{L}} \times 2.6\times10^{11}\ \text{L}$

$= 1.0\times10^{-5}$ mol/L $= 2.6\times10^{6}$ mol of $H_3O^+_{(aq)}$

(1 mark) **(2 marks)**

b. It would represent 2.6×10^{6} mol of $HNO_{3(aq)}$ since 1 mol of $HNO_{3(aq)}$ produces 1 mol of $H_3O^+_{(aq)}$ ions. **(2 marks)**

c. $Ca(OH)_{2(s)} + 2HNO_{3(aq)} \rightarrow 2HOH_{(l)} + Ca(NO_3)_{2(aq)}$ **(1 mark)**

d. At pH 6.00 the $\left[H_3O^+_{(aq)}\right]$ is 1.0×10^{-6} mol/L

and $n = CV$

$= 1.0\times10^{-6}\ \frac{\text{mol}}{\text{L}} \times 2.6\times10^{11}\ \text{L}$

$= 2.6\times10^{5}$ mol of H_3O^+

Therefore, you will have 2.6×10^{5} mol of $HNO_{3(aq)}$

You must neutralize 2.6×10^{6} mol $- 2.6\times10^{5}$ mol $= 2.34\times10^{6}$ mol of acid.

You need 1.17×10^{6} mol of $Ca(OH)_{2(s)}$ to neutralize the acid, so

$m = nM$

$= 1.17\times10^{6}$ mol $\times 74.10$ g/mol

$= 8.670\times10^{7}$ g

$= 8.7\times10^{7}$ g

$= 87$ tonnes (2 significant digits)

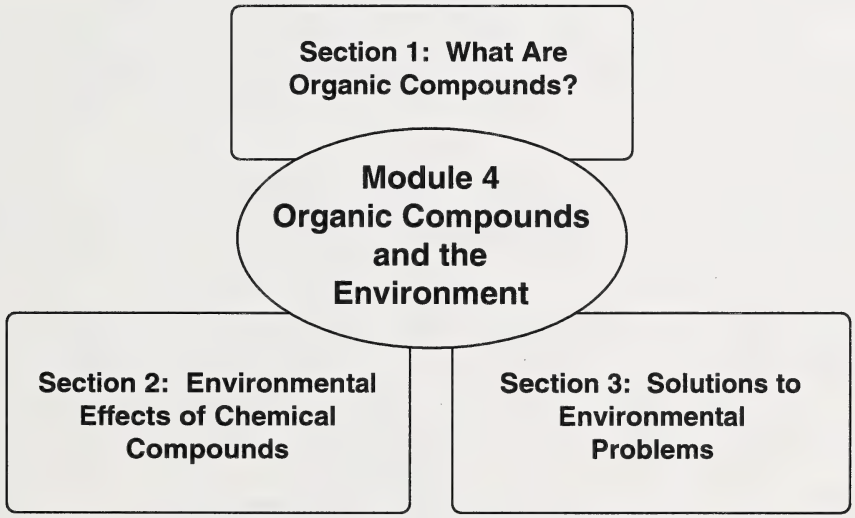
You would need 87 tonnes of $Ca(OH)_{2(s)}$ to bring the pH of the lake up to 6.00. **(4 marks)**

5. Your answer could be two of the following. Leaded gasoline has been phased out. DDT has been phased out. CFCs are being phased out. **(2 marks)**

Module 4: Organic Compounds and the Environment

Overview

The emphasis in this module is on the way in which organic compounds are produced and how their use modifies the environment. Section 1 begins with a review of the organic chemistry studied in Science 20, then identifies hydrocarbon derivatives, including alcohols, aldehydes, ketones, carboxylic acids, esters, and halogenated hydrocarbons, from the functional groups in their structure. The section goes on to provide the names, formulas, and common uses of compounds containing up to three or four carbon atoms for each of these categories. How some of these compounds are produced is the topic of the last activity in this section. Section 2 presents a discussion of the advantages and the disadvantages to the use of organic compounds and how these compounds create problems for the environment. Section 3 concludes the module with a discussion of the ways in which some of the problems that have been created by society can be identified and solved.


Section 1: What Are Organic Compounds?
Module 4 Organic Compounds and the Environment
Section 2: Environmental Effects of Chemical Compounds
Section 3: Solutions to Environmental Problems

Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**45 marks**
Section 2 Assignment	**35 marks**
Section 3 Assignment	**20 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

The amount of equipment needed in this module is relatively small. The compounds under discussion are for the most part toxic and so it is not advisable to be working with those compounds. Consequently the only materials needed are those for two activities in Section 1.

Section 1: Activity 3

Investigation: Preparing an Ester

Part A

- 100 mL graduated cylinder
- hot plate
- methanol, $CH_3OH_{(l)}$
- salicylic acid, $C_7H_6O_{3(s)}$
- concentrated sulphuric acid, $H_2SO_{4(aq)}$
- boiling stones
- 150 mL beaker
- 5 mL pipette
- test tube and test tube holder
- balance
- eye dropper

Part B

- No equipment is required for Part B.

Investigation: Making Soap

Part A

- clean fat (beef, pork, or lamb fat or lard from the supermarket)
- 3.5 mol/L $NaOH_{(aq)}$ solution
- 250 mL beaker
- 100 mL graduated cylinder
- glass stirring rod
- 2 milk carton bottoms with 2 cm high walls from 250 mL, 500 mL, or 1 L milk cartons
- hot plate
- thermometer

Part B

- video segment titled *Soaps from Organic Chemistry 2*
- VCR

Section 2: Activity 2

Investigation: Investigating an Environmental Issue

- No equipment is required for this investigation.

Section 3: Activity 2

Investigation: Exploring Alternatives to Chemical Insecticides

- No equipment is required for this investigation.

Section 3: Activity 3

Investigation: Formulating a Personal Action Plan

- No equipment is required for this investigation.

Additional Resources

Jenkins, F. etal. 1993. *Nelson Chemistry* Scarborough, Ontario: Nelson Canada.

Mandatory Videos

Section 1, Activity 3

Organic Chemistry 2, Soaps, TVOntario, ACCESS Network. Available from the Learning Resources Distributing Centre.

Section 2, Activity 1

Science, Technology and Society, Toxic Wastes, Alberta Education, ACCESS Network. Available from the Learning Resources Distributing Centre.

Optional Videos

Section 1, Enrichment

Organic Chemistry 2, Cosmetics, TVOntario, ACCESS Network.

Section 3, Activity 2

Hazardous Waste Management: Alberta's Success Story, Alberta Special Waste Management Corporation.

Section 1: What Are Organic Compounds?

Key Concepts

- Organic compounds are named according to a number of rules involving the number of carbon atoms on the longest straight carbon chain, the number and type of carbon-carbon double bonds, and the number and type of branch groups.
- Functional groups are specific groups that give certain organic compounds their particular properties.
- Organic compounds with specific properties studied in this module are alcohols, aldehydes, ketones, carboxylic acids, esters, and halogenated hydrocarbons.
- Organic compounds can be synthesized from other organic compounds.

Section 1: Assignment Answer Key (45 marks)

1. Carbon has the ability to form long chains of carbon atoms. Each additional carbon atom increases the number of compounds possible. In addition, the carbon chains may have multiple carbon-carbon bonds and many branches of various atoms or groups. Since there is so much complexity implicit in such an arrangement, there is also a great variety of forms possible. Each of these different forms provides a different organic compound.
(2 marks)

2. a. 2-methylpentane
b. 2,3,4,-trimethylhexane
c. 3-methyl-1-butene
d. 2-pentyne
e. 3,3-diethyl-1-pentene
(5 marks)

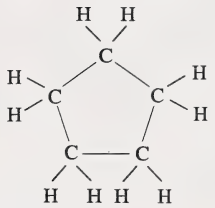
3. a. $CH_3 - CH_2 - CH(CH_3) - CH_2 - CH_2 - CH_3$

b. $CH_3 - C \equiv C - CH_3$

c. $CH_3 - CH_2 - CH(CH_3) - CH(CH_3) - CH(CH_3) - CH_2 - CH_2 - CH_2$

e. $CH_2 = CH(CH_2CH_3) - CH(CH_3) - CH_3$

d.



(5 marks)

4. $H-C(H)(Br)-C(H)(H)-C(H)(H)-H$ or $H-C(H)(H)-C(H)(H)-C(H)(Br)-H$ and $H-C(H)(H)-C(H)(Br)-C(H)(H)-H$

(2 marks)

5. a. The difference is that benzene is represented as having three equally spaced double bonds, whereas cyclohexane is represented as having only single bonds between the carbon atoms. **(1 mark)**

b. The presence of a benzene ring in a molecule imparts a distinct odour to the molecule. **(1 mark)**

6. a. Ketone: There is a carbonyl group (double oxygen bond with a carbon) with both R groups containing carbon atoms.

b. Carboxylic acid: There is a carboxyl group with one R group present.

c. Aldehyde: There is a carbonyl group with one R group being just a hydrogen atom.

d. Alcohol: There is a hydroxyl group bonded to a carbon chain.

e. Ester: It contains a double bond oxygen and a single bond oxygen, both bonded to the same carbon atom.
(10 marks; 1 mark for each class name, 1 mark for explanation)

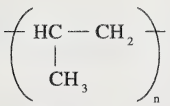
7. a. 2-butanone
   b. 2,2-dimethylpropanoic acid
   c. 2-methylpropanal
   d. 3-ethyl-5-methyl-3-hexanol
   e. ethyl ethanoate
   (5 marks)

8. A functional group causes a compound to react in a specific chemical fashion, thus giving the compound a characteristic set of chemical and physical properties. **(2 marks)**

9. a. CFCs were used extensively in industry because they were non-toxic and chemically unreactive under normal conditions. **(2 marks)**

   b. The IUPAC name for Freon 114 is 1,2-dichloro-1,1,2,2-tetrafluoroethane. **(1 mark)**

   c. The use of CFCs was discontinued because it has been found that CFCs remain in the atmosphere for a time sufficient to be carried to the top of the atmosphere where they decay under ultraviolet light and react with ozone. This process has destroyed some of the ozone, especially over the South Pole, thus thinning out the ozone layer which protects plants and animals at the surface from damaging radiation. **(2 marks)**

10. a. 
    (1 mark)

    b. The microorganisms that break down natural polymers such as silk or wool use special digestive enzymes. These microorganisms do not have the specific enzymes necessary to attack the bond which links monomers together for polypropylene. **(2 marks)**

11. Answers may vary, but your steps could be similar to these.

    Step 1: Wood chips are made into wood pulp using sodium hydroxide and sodium sulphide ($NaOH/Na_2S_{(aq)}$) to remove the polymer lignin which holds strands of the polymer cellulose together.

    Step 2: The wood pulp is then bleached with chlorine, sodium hypochlorite, chlorine dioxide, sodium hydroxide, and, in some cases, with oxygen and hydrogen peroxide as well.

    Step 3: Cellulose fibres are then flattened and roughened, and the fibre is sprayed on a wire mesh.

    Step 4: The paper is passed through a succession of smooth metal rollers to press the paper to desired thickness.
    (4 marks)

Section 2: Environmental Effects of Chemical Compounds

Key Concepts

- The use of various organic compounds and their disposal has caused many problems in the environment.
- The functional group that has caused the most problems are the halogenated hydrocarbons.
- Household garbage contains many organic compounds that may cause environmental problems when disposed of in improper landfills.
- Volatile organic compounds (VOCs) have created problems in the atmosphere including ozone depletion, smog, and acid rain.

Section 2: Assignment Answer Key (35 marks)

1. DDT breaks down in the environment to long-lasting, toxic byproducts. Those byproducts accumulate in fatty tissue. Biomagnification occurs causing long-term damage in animals. Humans have experienced aching joints and depression. Deformities have appeared in fish and the eggshells of some birds have become so thin they break before the chicks hatch. As a result the use of DDT has been banned in North American and many other parts of the world. **(3 marks)**

2. Your answer should be similar to the following but other risks and benefits may be acceptable. **(6 marks)**

RISKS AND BENEFITS OF ORGANOPHOSPHATES AND CARBAMATES AS INSECTICIDES	
Benefits	**Risks**
• Organophosphates break down into non-toxic compounds within days or weeks rather than years. • Carbamates break down quickly and do not accumulate in fatty tissue. • Without pesticides, a large portion of food would spoil. • Diseases that are carried by pests could be eliminated.	• If the pesticide kills all insects, then plants that require insects to pollinate would fail (includes many food crops). • Carbamates are very toxic to honey bees which affects both pollination and honey industry. • Perhaps there are undiscovered adverse effects from these pesticides.

3. Both 2,4,5-T and PCBs are contaminated in their manufacture with a class of substances called dioxins. Dioxins are extremely toxic and are known to cause birth defects and cancer. Rather than risk an increase in such diseases it has been decided to seek alternative substances to fill the role played by 2,4,5-T and PCBs. **(3 marks)**

4. The theory is certainly possible. Lead borne in water is known to cause brain damage, anemia, and loss of kidney function. It has been shown that children who have ingested lead develop mental handicaps and nervous damage. If lead was entering the water sources it would tend to affect only the wealthy, ruling classes since they were the ones serviced by the aqueducts. Lead pipes have been eliminated in water systems due to toxic hazards. All of these points support the fact that lead can enter the water and that it can affect the brain. **(5 marks total; 2 marks are awarded for communication)**

5. Many synthetic organic compounds are stable and appear to cause no adverse effects. However, over time these compounds accumulate in the environment and in the fatty tissues of animals. The adverse effects may not be observed until large amounts of the compound have accumulated. In addition, in some cases it may not be the organic compound itself but an organic contaminant in the compound that causes the problem. As a result it may be years of accumulation before the synthetic organic compound that is causing the adverse effects is even isolated. **(5 marks total; 2 marks are awarded for communication)**

6. Volatile organic carbons from vegetation, gasoline, discarded plastics, and solvents rise into the atmosphere and mix with nitrogen dioxide from the atmosphere to form peroxyacetyl nitrates. The VOCs also react with the nitrogen monoxides from vehicle exhaust and industrial processes making them unavailable to accept an oxygen from any ozone formed, causing an increase in the ozone present. **(3 marks)**

7. Examples of volatile organic compounds are gasoline, paint thinners, and alcohols in deodorants and hair sprays. **(2 marks)**

8. a. A bottle that can be opened and closed by remote control at the specified depth is lowered. The sample of water inside is immediately measured for oxygen content; the bottle is then stored at 20°C for 5 days. At the end of that time the sample is again measured for oxygen content. The reduction in the amount of oxygen is called the biological oxygen demand. **(3 marks)**

   b. The BOD gives a rough measure of how polluted a body of water is and how productive the water can be. **(2 marks)**

9. The sample is carried through a column, formed from a very fine tube, which has been coated with a liquid. As the sample proceeds through the tube, the different chemicals in the gas will travel at different rates depending on how they interact with the liquid coating. By collecting data for the different gases as they progress and comparing their transit time to times measured for known substances, it is possible to find out what chemicals and what amounts are present. **(3 marks)**

Section 3: Solutions to Environmental Problems

Key Concepts

- The problem of household garbage can be reduced by reusing and recycling as much material as possible as well as reducing the amount used initially.
- Hazardous chemicals can be reduced by separating in the home and sending them to appropriate collection sites.
- All collected hazardous chemicals in Alberta are sent to the Alberta Special Waste Disposal Plant in Swan Hills, Alberta, where they are reduced to elemental compounds before disposal.
- Industries have been working for the past 20 to 25 years to reduce pollution with significant reductions being achieved.
- Each individual can do much to reduce the pollution by participating in waste reduction and recycling programs.

Section 3: Assignment Answer Key (20 marks)

1. Synthetic polymers, such as plastic, are formed using fossil fuels as stock feed. The environmental degradation inherent in extracting the fossil fuels is mainly found in the release of nitrogen oxides and volatile organic carbons into the atmosphere from the exhaust of the engines that drive the machinery.

   During the processing of the fossil fuels to plastic, corrosive agents, such as acids and bases are needed to precipitate the reactions causing polymerization. Those corrosive agents must be manufactured, transported, and stored, and so are susceptible to spills which damage the ecosystem.

   Plastics in their final form are virtually non-biodegradable and so tend to accumulate in the environment.

   Treating the plastics, by adding substances to make them more biodegradable, causes the treated plastic to be unsuitable for recycling and possibly adds toxic byproducts from the breakdown into the environment. Incineration creates toxic gases and so is not an ideal solution.

   To make recycling more effective, it will be necessary to label each plastic manufactured with an identification so that sorting can occur. At present sorting is not possible and only "plastic lumber" is produced from recycled plastic.
   (8 marks total; 2 marks for communication)

2. The substance is incinerated at very high temperatures to produce non-toxic ash. The gasses from this process are scrubbed clean of any pollutants before being released into the atmosphere. The ash is then mixed with a stabilizer such as lime and deposited in a specially constructed landfill. Wells dug around the perimeter of the landfill monitor the site to detect any leakage. Liquids from the process are usually stabilized by precipitation or adjusting their pH and injected into very deep wells located below any water sources which may be used. **(4 marks)**

3. Four things an individual can do to reduce the amount of plastic waste generated are as follows.

   - Don't buy articles that come with excessive packaging.
   - Buy products in reusable or recyclable containers.
   - Write to manufacturers and ask them to change the way in which they package their products.
   - Avoid disposable items such as pens, cameras, and plastics utensils.

   (4 marks)

4. Your answer should be similar to the following. You should have at least two benefits and two risks. **(4 marks)**

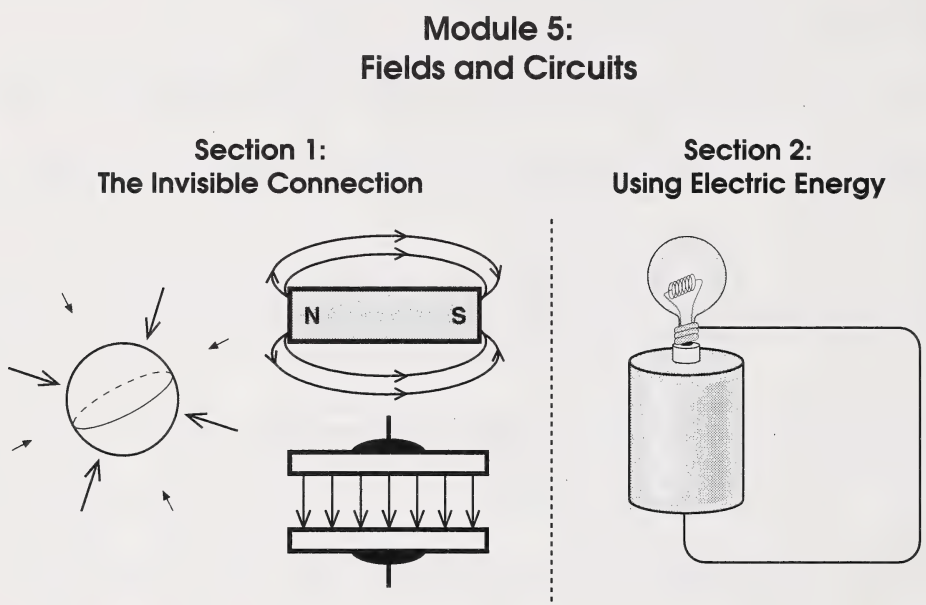
BENEFITS AND RISKS OF A GENETICALLY ENGINEERED VIRUS AS AN INSECTICIDE	
Benefits	**Risks**
• A genetically engineered virus would act quicker to kill the insect pest. This would result in less crop damage. • The production and use of toxic chemicals would be halted. • It would be effective against insects that have developed resistance to conventional pesticides.	• Once released into the environment there may be no control over the virus. • There is no guarantee the virus will stay effective since viruses mutate. • Mutation could cause the virus to change and attack targets for which it was not meant.

Module 5: Fields and Circuits

Overview

This module has two distinct parts. The first section introduces students to the concept of a field that is used in science to describe gravitational, electric, and magnetic phenomenon. Students analyse data and move from an understanding of forces to the more subtle concept of fields.

Section 2 is a survey of the applications of electric energy. Although there is some connection to the first section, for the most part this section is much less theoretical and more practical as students learn to use electronic instruments to build and test circuits.



Evaluation

The evaluation of this module will be based on two assignments:

Section 1 Assignment	**45 marks**
Section 2 Assignment	**55 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

The following is a list of materials and equipment necessary for an individual to complete the investigations and activities in Module 5. Adjust the amount of equipment if more than one individual is involved.

Section 1: Activity 5

Investigation: Properties of Bar Magnets

- two bar magnets
- a small magnetic compass
- iron filings
- a sheet of paper or a glass plate that measures approximately 22 cm × 28 cm

Section 2: Activity 2

Investigation: Measuring Potential Difference and Current for a Resistor

- a multimeter (or an ammeter and a voltmeter)
- a DC power supply capable of producing at least six different output voltages
- three resistors that are rated at 0.5 W: 1000 Ω, 1500 Ω, and 2000 Ω
- four test leads with alligator clips at each end
- a power outlet into which you can plug your power supply

Section 2: Activity 3

Investigation: The Series Circuit

- a multimeter capable of measuring potential difference (0 V to 20 V), current (0 mA to 20 mA), and resistance (200 Ω to 5000 Ω)
- a DC power supply capable of producing at least six different output voltages (0 V to 20 V)
- three resistors that are rated at 0.5 W: 510 Ω, 1000 Ω, and 1500 Ω
- six test leads with alligator clips at both ends
- three pieces of masking tape, each measuring about 40 mm by 5 mm

Investigation: The Parallel Circuit

- The same materials for the previous investigation are used for this one.

Additional Resources

Alberta Education. 1992. *Senior High Science Teacher Resource Manual.* Edmonton, Alberta: Department of Education, Curriculum Branch.

Giancoli, Douglas C. 1991. *Physics* 3rd edition. Toronto, Ontario: Prentice-Hall Canada Inc.

Hewitt, Paul G. 1987. *Conceptual Physics.* Don Mills, Ontario: Addison-Wesley Publishing Company Inc.

Kane, Joseph W., Sternheim, Morton M. 1980. *Physics: SI Version.* Toronto, Ontario: John Wiley and Sons Inc.

Martindale, David G., et al. 1992. *Fundamentals of Physics: Combined Edition.* Montreal, Quebec: D.C. Heath Canada Ltd.

Zitzewitz, Paul W., et al. 1992. *Physics: Principles and Problems.* Teacher Resource Package. Toronto, Ontario: Maxwell Macmillan Canada Inc.

The *Physics: Principles and Problems* textbook is the one that the ADLC Physics 20 and 30 materials wrap around.

The resource package includes planning guides, strategies for teaching key concepts, answers to end of chapter problems, suggestions for enrichment and remediation, transparency masters, evaluation instruments, and supplemental lessons.

The Giancoli book is the best teacher reference for the physics concepts, providing explanations, ideas for problems, and applications at the college level. The Kane and Sternheim book is a college text that is great for the biological applications of physics. Hewitt's book takes a non-mathematical approach to physics and provides very good explanations of basic concepts at the high school level. Another high school text is the Martindale book which has a wonderful assortment of problems.

The *Senior High Science Teacher Resource Manual* includes a great variety of ideas to help teachers implement the vision of the new science curriculum.

Possible Media

Videocassettes

Electricity: Conductors and Insulators, Current Electricity, Potential Difference, Resistance TVOntario (Available through ACCESS Network)

Electromagnetism: Earth's Magnetic Field TVOntario (Available through ACCESS Network)

These programs are only 10 min long and yet they provide students with valuable computer animation sequences that help the students master the key concepts. These programs may also be purchased from the Learning Resources Distributing Centre.

Section 1: The Invisible Connection

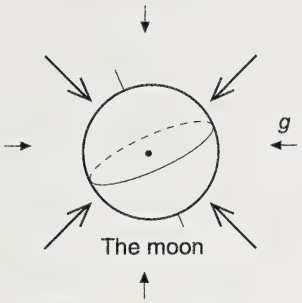
This section uses the problem of action-at-a-distance (explaining how forces can act on an object that is some distance from the source) to introduce the concepts of gravitational, electric, and magnetic fields. These ideas are subtle and are not easily grasped by students, so you may find it helpful to utilize some of the design features of this section into your own teaching.

Gravitational fields and electric fields are very similar in many respects, so these concepts were developed along parallel lines to help students see the trends. In both cases, starting with the force equations is a crucial first step because if the students don't understand the forces, then it's unlikely that they will understand the fields.

Magnetic fields can be grasped reasonably well if the students complete the investigation with the bar magnets, compass, and iron filings.

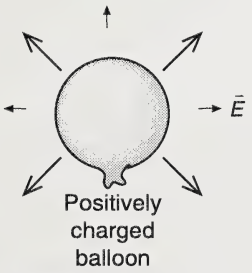
Section 1: Assignment Answer Key (45 marks)

1. a.



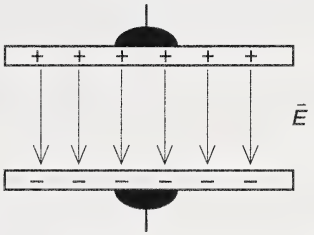
(2 marks)

b.



(2 marks)

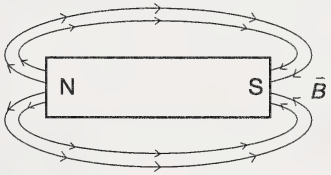
c.



Two oppositely charged metal plates

(2 marks)

d.



A bar magnet

(2 marks)

2. The similarities between electric fields and gravitational fields include the following:

- Both fields have the strength of the field proportional to the inverse square of the distance of separation.
- Both fields are proportional to the magnitude of the source.
- Both fields can be drawn with radial lines drawn from the centre of a spherical source.

The differences between electric fields and gravitational fields include the following:

- The gravitational field is always directed towards the source, while the electric field can be towards or away from the source, depending on its sign.
- The gravitational field allows a gravitational force to act on a mass while the electric field allows an electric force to act on a charge.

(6 marks)

3. The similarities between electric fields and magnetic fields include the following:

- Both fields are caused by the presence of electric charge.
- Both fields can exert forces on charged particles.

The differences between electric fields and magnetic fields include the following:

- Magnetic fields are caused by moving charges and can only act on moving charges, while electric fields originate and can act on stationary charges or on moving charges.

- Magnetic field lines always form closed loops, while electric field lines can form straight lines that go indefinitely out into space.

(4 marks)

4. **Textbook question 13:** The magnetosphere is the region of space surrounding Earth that is influenced by Earth's magnetic field. The magnetosphere acts like a large umbrella to shield Earth from the stream of charged particles emitted by the sun called the solar wind. If this shielding did not exist, then intense electric and magnetic fields would be created in the atmosphere by the charged particles of the solar wind. This would place limitations on the use of satellite, radio, and television communications. It could also create abnormal weather conditions. **(4 marks)**

5. $m_J = 1.90 \times 10^{27}\ \text{kg}$

$r_J = 7.14 \times 10^4\ \text{km}$

$= 7.14 \times 10^7\ \text{m}$

$g = ?$

$$g = \frac{Gm_J}{r_J^2}$$

$$= \frac{\left(6.67 \times 10^{-11}\ \text{N} \bullet \text{m}^2/\text{kg}^2\right)\left(1.90 \times 10^{27}\ \text{kg}\right)}{\left(7.14 \times 10^7\ \text{m}\right)^2}$$

$$= 24.9 \frac{\text{N}}{\text{kg}}$$

The value of g on Jupiter is 24.9 N/kg. **(4 marks)**

6. **Textbook question 2:** The species in these regions were already adapted to a cooler environment with long periods of darkness. Other plants and animals in this environment would be similarly adapted so the food chain would be less disrupted than it would be in warmer climates. **(2 marks)**

Textbook question 3:

$M_{\text{proton}} = 1.67 \times 10^{-27}\ \text{kg}$

$q_{\text{proton}} = 1.6 \times 10^{-19}\ \text{C}$

$r = ?$

$\frac{F_{\text{el}}}{F_g} = ?$

$$\frac{F_{\text{el}}}{F_g} = \frac{\frac{kq_p q_p}{1^2}}{\frac{Gm_p m_p}{1^2}}$$

$$= \frac{kq_p q_p}{Gm_p m_p}$$

$$= \frac{\left(8.99 \times 10^9\ \frac{\text{N} \bullet \text{m}^2}{\text{C}^2}\right)\left(1.6 \times 10^{-19}\ \text{C}\right)\left(1.6 \times 10^{-19}\ \text{C}\right)}{\left(6.67 \times 10^{-11}\ \frac{\text{N} \bullet \text{m}^2}{\text{kg}^2}\right)\left(1.67 \times 10^{-27}\ \text{kg}\right)\left(1.67 \times 10^{-27}\ \text{kg}\right)}$$

$$= 1.2 \times 10^{36}$$

The gravitational force is a factor of 10^{36} smaller than the electric force, which means that it is not significant. **(4 marks)**

Textbook question 4: A cassette or VCR tape has information stored by a magnetic coating that is attached to the tape. Devices like hi-fi speakers and operating electric motors are surrounded by large magnetic fields that could rearrange the magnetic particles on the tape. This would destroy the information stored on the tape leaving the tape either partly or completely erased. **(3 marks)**

7. a. The gravitational field in this story was provided by Earth. The field is directed down towards the centre of Earth, which is the direction that it exerts a force on a mass. When the vase was nudged off the edge of the table, the table was no longer able to provide an upward force to counter the force of gravity. The gravitational field of Earth allowed Earth to exert a downward force on the vase. **(4 marks)**

   b. The electric field was responsible for the person's hair being repelled by the shirt sleeve. As the acrylic sweater was pulled off, charge was transferred between the shirt sleeve and the sweater and between the hair and the sweater. The person's shirt was left with a net charge and it surrounded itself with an electric field. The hairs on the person's head were repelled by the person's shirt sleeve due to the electric field surrounding the shirt sleeve. The moist environment of the bathroom would solve this problem by allowing the person's body to discharge. **(4 marks)**

   c. The speaker created an unwanted magnetic field that redirected the electron beam within the television set. Instead of the electrons being directed solely by the electromagnets within the set, they were sent off course by the magnetic field of the speaker. **(2 marks)**

Section 2: Using Electric Energy

This section is much more practical than the first as the focus is on the practical applications of electric energy through simple electric circuits. The TVOntario video programs (*Electricity: Current Electricity, Potential Difference and Resistance*) are essential because they give the students the necessary background information in a very effective format.

Take the necessary time to coach students about how to use the equipment that is available. This is one topic that is best learned by doing, so it's important that students learn to use the multimeter and power supply properly. One suggestion is to carefully do each of the investigations yourself before the students do. This may help you to anticipate likely difficulties that they will have. The final piece of advice is to have plenty of fuses handy because students frequently find it hard to remember all the necessary double checks when they start using the multimeters.

Section 2: Assignment Answer Key (55 marks)

1. **Textbook question 1:** Direct current involves the electrons passing in one overall direction as they travel around the loop of a circuit. A bulb connected to a flashlight battery is an example of a DC circuit. **(2 marks)**

   Alternating current involves the electrons periodically changing direction as they respond to the external power source that supplies energy to the circuit. Any appliance connected to a wall outlet has an alternating current flowing through its power cord. **(2 marks)**

2. **Textbook question 5:** If the cord to your kettle gets very hot, then there are a couple of possible explanations. The kettle could have a short developing within its heating element that causes the kettle to draw too much current. A more likely explanation concerns the cord itself. If the cord was continually wrapped the same way around the kettle, then the wire within the cord could be developing a spot where it is thinner and therefore has a higher resistance. It is also possible that the cord consists of wires that are too small in diameter. This small diameter means that the cord itself starts to have enough resistance to heat up. **(4 marks)**

   Textbook question 6: If the potential difference doubles, then the current drawn by the resistor would double. This is a matter of concern because even small increases in current can lead to overheating and the potential for electric shock. **(3 marks)**

Textbook question 7:

$V = 110\,\text{V}$

$I = 6.5\,\text{A}$

cost = ?

rate = \$25 / GJ

$$t = 2\ \text{weeks} \times \left[\frac{7\,\text{d}}{1\ \text{week}}\right] \times \left[\frac{24\,\text{h}}{1\,\text{d}}\right] \times \left[\frac{60\ \text{min}}{1\,\text{h}}\right] \times \left[\frac{60\,\text{s}}{1\ \text{min}}\right]$$

$$= 1.21 \times 10^{6}\ \text{s}$$

Step 1: Calculate the power.

$$P = IV$$
$$= (6.5\,\text{A})(110\,\text{V})$$
$$= 715\,\text{V} \bullet \text{A}$$
$$= 715\,\text{W}$$
$$= 715\,\text{J/s}$$

Step 2: Calculate the energy.

$$E_e = Pt$$
$$= (715\text{J/s})\left(1.21 \times 10^{6}\ \text{s}\right)$$
$$= 8.65 \times 10^{8}\ \text{J}$$
$$= 0.865\text{GJ}$$

Note: $1\text{GJ} = 10^{9}\ \text{J}$

Step 3: Calculate the cost.

$$\text{cost} = (0.865\,\text{GJ})(\$25/\text{GJ})$$
$$= \$21.62$$

The cost of operating the refrigerator is approximately \$22.
(7 marks)

Textbook question 8: Brass is stronger and harder than copper so it wears better. In additional, brass is more resistant to corrosion than copper. **(2 marks)**

3. **Textbook question 10:** The electric current causes the muscles in the person's body to contract making their body rigid to the point that it is beyond the control of the person's nervous system. To detach someone in this state is the last thing you want to do because if you grab them, you will end up in the same state. It's best to use a long, non-conducting object like a broom or wooden stick to either move the live wire or move the person's body away from the wire. Another option may be to reach the control panel and shut off the source of current to the person. **(3 marks)**

4. a. $E_e = 25\,\text{J}$

$t = 30\,\text{ms}$

$= 3.0 \times 10^{-3}\ \text{s}$

$R = 50\,\Omega$

$I = ?$

Step 1: Calculate the power.

$$P = \frac{E_e}{t}$$
$$= \frac{25\text{J}}{3.0\times10^{-3}\text{ s}}$$
$$= 8333\text{J/s}$$
$$= 8.3\times10^{3}\text{ W}$$

Step 2: Calculate the current.

$$P = I^2 R$$
$$I^2 = \frac{P}{R}$$
$$I = \sqrt{\frac{P}{R}}$$
$$I = \sqrt{\frac{8333\text{J/S}}{50\,\Omega}}$$
$$= \sqrt{166.\bar{6}\text{ A}^2}$$
$$= 12.9\text{ A}$$

The current put into the patient's body in this case is 12.9 A.
(5 marks)

b. $E_e = 360\text{J}$
$t = 3.0\text{ms}$
$= 3.0\times10^{-3}\text{ s}$
$I = 49\text{A}$
$R = 50\,\Omega$
$V = ?$

$$V = IR$$
$$= (49\text{ A})(50\,\Omega)$$
$$= 2450\text{ V}$$
$$= 2.5\times10^{3}\text{ V}$$

The potential difference across the electrodes is 2.5×10^{3} V.
(3 marks)

5. The equivalent resistance of this circuit equals the slope of the graph.

$$R_T = \text{slope} = \frac{\text{rise}}{\text{run}}$$
$$= \frac{5.7\text{V} - 1.2\text{V}}{5.0\times10^{-3}\text{ A} - 1.0\times10^{-3}\text{ A}}$$
$$= \frac{4.5\text{V}}{4.0\times10^{-3}\text{ A}}$$
$$= 1125\frac{\text{V}}{\text{A}}$$
$$= 1.1\times10^{3}\,\Omega$$

Since this is a series circuit, the sum of the resistance values must equal the equivalent resistance.

$$R_T = R + R$$
$$R_T = 2R$$
$$R = \frac{R_T}{2}$$
$$R = \frac{1125\,\Omega}{2}$$
$$= 562.5\,\Omega$$
$$= 5.6\times10^{2}\,\Omega$$

The value of each resistor is $5.6\times10^{2}\,\Omega$.
(8 marks)

6. **Textbook question 5:**

$V = 110\,\text{V}$

$R = 65\,\Omega$

$$P = IV$$
$$= \frac{V^2}{R} \qquad \text{since } \left(I = \frac{V}{R} \right)$$
$$= \frac{(110\,\text{V})^2}{65\,\Omega}$$
$$= 186\,\text{W}$$

$P = 186\text{W}$

$t = 153\text{d}$ (May 1 to September 30)

$= 3672\text{h}$

$= 1.32 \times 10^7\ \text{s}$

$$E = Pt$$
$$= 186\,\text{W}\ (1.32 \times 10^7\ \text{s})$$
$$= 2.46 \times 10^9\ \text{W} \bullet \text{s}$$
$$= 2.46 \times 10^9\ \text{J}$$
$$= 2.46\,\text{GJ}$$

$$\text{cost} = 2.46\,\text{GJ} \times \$20/\text{GJ}$$
$$= \$49.14$$

It would cost approximately $49 to run the furnace continuously from May 1 to September 30.
(4 marks)

7. Student essays should be similar to the following.

Safety precautions must always be followed when handling electrical devices. The four safety precautions presented in this module helped to complete the investigations safely.

The first safety warning is very similar to the predicament of a parachutist shown in the video programs. By touching one part of your body to a grounded object while another part touches part of a live circuit, you can create a high potential difference across your body, which can cause a current to flow. Since even small amounts of current are dangerous, you should insulate your body from this circumstance and you should keep your body's resistance high by keeping dry.

The second safety warning relates to the fact that the fuse in the meter is designed to protect both you and the meter from high currents. For most meters this is anything over 0.5A. If you replaced the fuse with a higher current rating, then more current would flow than the meter is designed to handle. This could expose you to shock and the internal parts of the meter to serious overheating.

The third safety warning indicates that the meter has limits as to the potential difference values that it can safely handle. If the potential difference is too high, then the resulting current flow could be dangerous to you (as described in the first safety warning) or damaging to the inside of the meter (as described in the second safety warning).

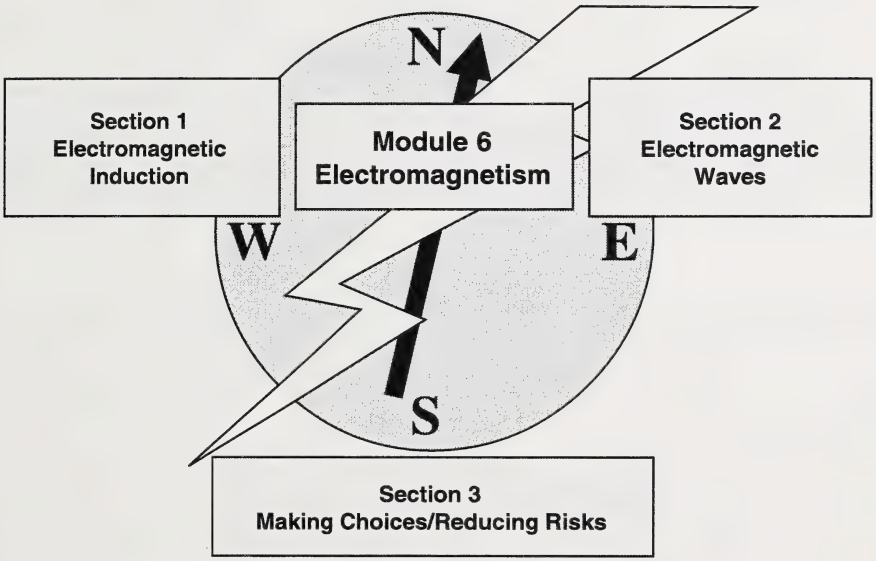
The last safety warning relates to the fact that the resistors convert electric energy to thermal energy. Resistors are devices that are designed to hinder or resist the flow of electrons through them. Some of the electrons that flow through a resistor collide with the ions in the network and cause them to increase their rate of vibration. This corresponds to an increase in temperature and the production of thermal energy.

The safety precautions followed in this course helped to work with circuits, use and maintain electrical devices properly, and to observe caution regarding the handling of resistors. **(12 marks total; 2 marks are awarded for communication)**

Module 6: Electromagnetism

Overview

This module begins with the relationship between electricity and magnetism as the students learn three hand rules to describe electromagnetic interactions. These ideas are eventually extended to motors, generators, transformers, and the creation of electromagnetic waves. The module ends with students doing an indepth study of the effects of UV light on the skin by analysing the risks and benefits of suntanning.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**40 marks**
Section 2 Assignment	**30 marks**
Section 3 Assignment	**30 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

The following is a list of materials and equipment necessary for an individual to complete the investigations and activities in Module 6. Adjust the amount of equipment if more than one individual is involved.

Section 1: Activity 2

Investigation: Building an Electric Motor

- a felt pen or other cylindrical object with a diameter of about 1 cm
- 50 cm of enamelled magnet wire (28 gauge)
- two copper-coloured paper clips
- small piece of fine sandpaper (220 grit): 5 cm × 5 cm
- two pieces of masking tape: 18 mm × 50 mm
- 30 Ω power resistor: 5 W power handling
- DC power supply capable of 12 V output
- three connecting wires with alligator clips at each end
- bar magnet

Section 1: Activity 3

Investigation: Generating Electricity

- 7 m of 28 gauge enamelled magnet wire
- a sensitive galvanometer (μA) or multimeter with a microampere scale for DC current measurements
- two connecting wires with alligator clips at both ends
- bar magnet

Investigation: Building a Transformer

- two pieces of 28 gauge enamelled magnet wire—7.2 m long and 3.6 m long
- a steel loose-leaf ring: 1 inch size
- DC power supply capable of 12 V output
- a 30 Ω power resistor—5 W power handling
- a sensitive galvanometer (μA) or a multimeter with a microampere scale for DC current measurements
- two pieces of masking tape, each 10 cm long

Section 2: Activity 1

Investigation: Induction at a Distance

- the coil constructed in Section 1 (made with 7 m of 28 gauge enamelled magnet wire)
- a steel bolt
- a variable power supply capable of 12-V DC output
- a radio, preferably portable
- a 30-Ω power resistor rated at 5 W

Section 2: Activity 3

Investigation: The Reflection of Light

- a ruler and a protractor
- a mirror
- 3 straight pins
- a piece of corrugated cardboard or other soft material to hold the pins
- pencil and plain paper

Investigation: The Refraction of Light

- ruler and protractor
- 3 straight pins
- a block of glass: approximately 8 cm × 8 cm × 1 cm thick
- pencil and plain paper

Investigation: Observing the Polarization of Light

- two polarizing filters
- a light source
- a smooth horizontal surface

Additional Resources

The same resources listed for Module 5 can provide additional support and information for teaching Module 6. Please refer to the list presented for Module 5.

Mandatory Videos

Section 1: Activity 1

Electromagnetism: Magnetism and Electron Flow, TVOntario, 1987.

Electromagnetism: Domain Theory, TVOntario, 1987.

Electromagnetism: The Motor Principle, TVOntario, 1987.

Section 1: Activity 3

Electromagnetism: Electromagnetic Induction, TVOntario, 1987.

Section 2: Activity 1

Wave-Particle Duality: The Electromagnetic Model, TVOntario, 1984.

These programs are each 10 minutes long and were originally produced by TVOntario. They are available through ACCESS Network or the Learning Resources Distributing Centre.

Other Videos

An additional videocassette that could be used to supplement Section 3 is called *Your Skin and the Sun* which can be borrowed from the nearest office of the Canadian Cancer Society.

Note: Some of the suggested media may not be authorized by Alberta Education. Teachers should use their own discretion regarding the use of these resources in their classroom.

Section 1: Electromagnetic Induction

Key Concepts

- A conductor carrying a charge produces a magnetic field around itself.
- The left-hand rule can be used to show the direction of the magnetic field relative to the electron flow.
- Two parallel current-carrying wires will exert forces on each other.
- A magnetic force is exerted on a current-carrying wire placed at right angles to a magnetic field. This is called the motor principle.
- The motor principle can be applied to produce an electric motor.
- Electromagnetic induction is when a current is induced in a coil by changing the magnetic field strength within the coil.
- A transformer is an electromagnetic induction device which can be used to increase or decrease the voltage in a wire.

Teaching Suggestions

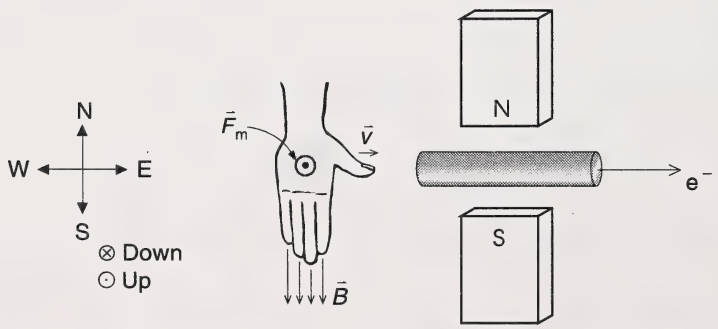
In this section students learn to qualitatively describe the operation of devices like motors, generators, and transformers. The whole key to their understanding lies in the mastery of the hand rules in the first activity so this activity should not be rushed. The video programs are an excellent resource that you should use liberally.

The information in the remaining activities can be conceptually quite challenging for students so you may find it helpful to rehearse your explanations so that you can use the hand rules in a consistent way.

Section 1: Assignment Answer Key (40 marks)

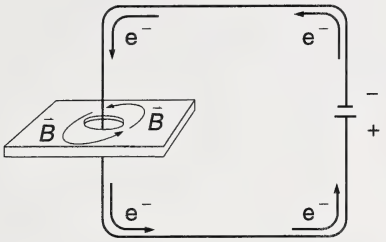
1. Oersted discovered that an electric current flowing through a conductor generates a circular magnetic field. Ampère discovered that two parallel current-carrying wires will exert forces on each other due to the interaction of their magnetic fields. **(3 marks)**

2.

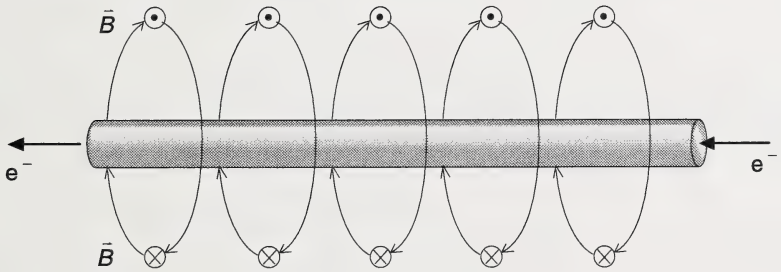


Using the left-hand rule for force it can be shown that the force on the conductor should be up. **(3 marks)**

3. Electron flow is negative to positive, so by using the left-hand rule you can determine that the direction of the magnetic field around the wire should be counterclockwise. Note: Only the diagram is required.



(2 marks)

4. 

The left-hand rule for conductors is used to determine the direction of electron flow through the conductor. The hand is held palm out from the page with fingers curled toward you and thumb pointing left in direction of current flow. **(3 marks)**

5. a. Since the input voltage to the primary coil is lower than the output voltage to the secondary coil, this is a step-up transformer. **(2 marks)**

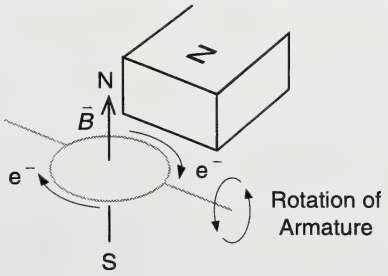
b. $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$= \frac{24\,000\ \text{V}}{120\ \text{V}}$

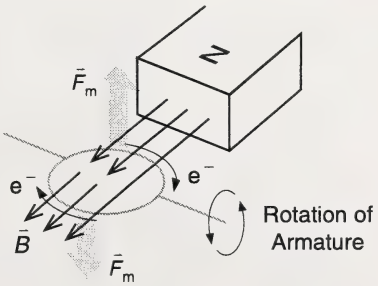
$= 200$

There should be 200 times as many turns on the secondary coil as there are on the primary coil. **(3 marks)**

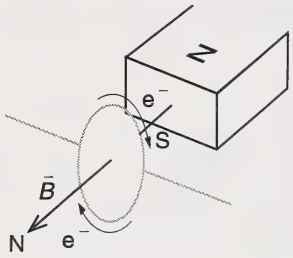
6. a. The left-hand rule for coils predicts that the top of the armature would be a north pole. This means that the top half of the armature would be repelled and would spin away from the north pole of the bar magnet. **(3 marks)**



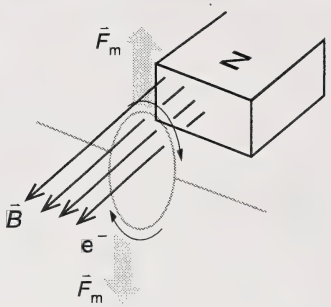
b. The left-hand rule for force predicts that the side of the armature close to the magnet will be forced up while the other side will be forced down. **(3 marks)**



7. a. The left-hand rule for coils shows that the end of the armature closest to the bar magnet is a south pole. This would be attracted to the north pole of the bar magnet and would actually resist motion of the coil. **(3 marks)**



b. The left-hand rule for force shows that the top of the loop would be forced up while the bottom of the loop would be forced down. Since the loop is already in a vertical position this does not help to turn the loop. **(3 marks)**



c. The loop continues to turn in this position due to the motion it developed in the previous position. According to Newton's first law, objects maintain their motion unless they are acted upon by an external force. As the answer to part b. indicates, the force does not act to oppose the spinning motion. The force from the attraction of the north pole of the magnet and the south pole of the coil does not to stop the coil from rotating. **(2 marks)**

8. The answer to this question is similar to the answer to 7. c. The motion of the loop (due to the force exerted in the first position shown) allows it to continue to spin through this position. **(2 marks)**

9. The contacts of the armature are only in contact with the supports for half the time during each rotation. This means that electrons are only flowing through the armature for half the time that the motor spins.

   This is further complicated by the fact that the motor only experiences a force that causes it to rotate for one-quarter of its entire cycle. This means that for the other three-quarters of the cycle the motor must *coast* until it can experience a force again. Clearly if the motor spends three-quarters of its time spinning from a previous push it is very important for the motor to lose as little energy as possible so that it will make it until the next boost of energy.

   In a real motor with a split-ring commutator the current is reversed every half turn thus giving two instances where the motor experiences a force that causes it to rotate. The result is that the armature in the real motor only coasts for one-half of its cycle. **(8 marks total; 2 marks for communication)**

Section 2: Electromagnetic Waves

Key Concepts

- Changing electric and magnetic fields produce waves which travel through space.
- The electromagnetic spectrum is the complete range of electromagnetic waves ordered according to frequency or wavelength.
- Velocity, frequency, or wavelength can be calculated using the formula $c = f\lambda$, where c is the speed of light in a vacuum, f is the frequency of the wave, and λ is the length of the wave.
- The electromagnetic spectrum consists of radio waves, microwaves, infrared radiation, visible light waves, ultraviolet radiation, x-rays, and gamma radiation.
- Radio waves provide AM, FM, and television signals.
- Microwaves are used in microwave ovens, and radar and satellite communications.
- Infrared radiation provides all our heat requirements.

- Visible light is at the frequency to which the eyes of most living things respond as well as the frequency at which chemical changes, such as development of photographic film and photosynthesis, take place.
- Ultraviolet light is at the frequency at which suntanning takes place.
- X-rays provide medical staff with pictures of bones as well as images of soft body parts.
- Gamma rays are emitted by radioactive material and are the most hazardous form of radiation.
- A useful application of several frequencies of electromagnetic radiation is remote sensing technology.
- Visible light can be used to study the properties of electromagnetic radiation in general.
- Three important properties of visible light and electromagnetic radiation in general are reflection, refraction, and polarization.

Teaching Suggestions

This section is an extension of the first but it is more descriptive and is therefore not nearly as difficult. The investigation at the beginning of Activity 1 provides a good link between electromagnetic induction and the electromagnetic spectrum which is studied in Activity 2. Activity 3 introduces students to three properties of light: reflection, refraction, and polarization. Care should be taken to keep the study of these topics as qualitative as possible. For example, Snell's law as developed in the textbook clearly goes beyond the program of studies.

Section 2: Assignment Answer Key (30 marks)

1. a. The source of all electromagnetic radiation is an accelerating **charged** particle. If the accelerating particle does not have a net charge, no radiation will be created. **(2 marks)**

   b. Radiation with a frequency of 1.0×10^{15} Hz is classified as **ultraviolet** radiation. A calculation confirms that the wavelength is shorter than that for visible light.

   $f = 1.0\times10^{15}$ Hz
   $c = 3.00\times10^{8}$ m/s
   $\lambda = ?$

   $c = \lambda f$

   $\lambda = \frac{c}{f}$

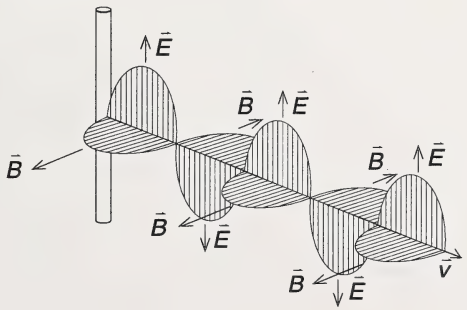
   $= \frac{3.00\times10^{8}\text{ m/s}}{1.0\times10^{15}\text{ Hz}}$

   $= 3.0\times10^{-7}$ m

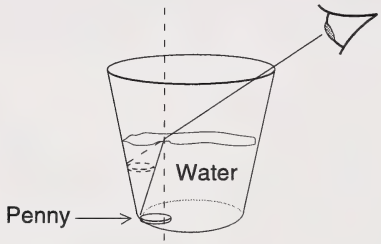
   (2 marks)

   c. When an electromagnetic wave slows down due to a sudden change in the medium, the wave bends **towards** the normal. This is the case for light passing from air into glass. **(2 marks)**

2. An electromagnetic wave propagates through space by the changing electric field creating a changing magnetic field, which in turn creates a changing electric field, and so on. As shown in the diagram, these fields act perpendicularly to each other and to the direction of the wave velocity. Note that in this example the electric fields are in the vertical plane, while the magnetic fields are in the horizontal plane. **(6 marks)**



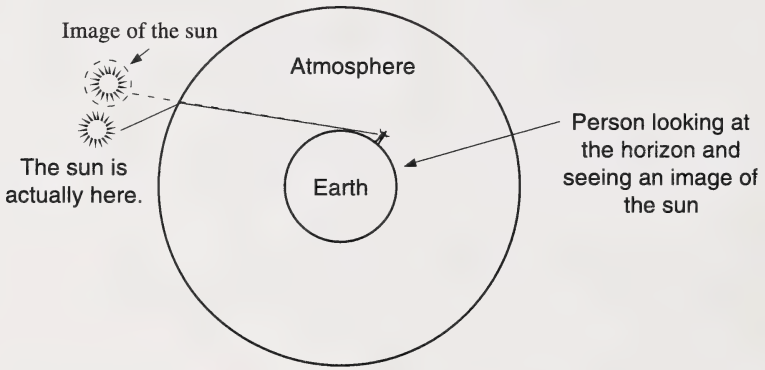
3. Light is refracted to your eyes. Your eyes perceive that the light travels in a straight line, creating the image shown. **(2 marks)**



4. The first reason why this is unlikely has to do with the fact that the vertically oriented antenna will tend to produce radio waves that have the electric field component in the vertical plane. In other words the waves produced would be vertically polarized. Since the wire on the fence runs horizontally it is unlikely that the charges could be made to vibrate with the vertical electric field.

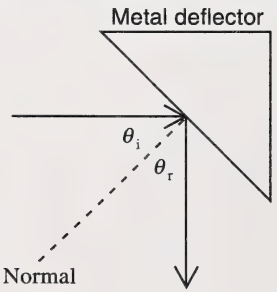
   The second reason has to do with the fact that radio waves carry relatively small amounts of energy as they are long wavelength, low frequency electromagnetic waves. The electromagnetic waves that carry the most energy are short wavelength, high frequency electromagnetic waves. **(6 marks)**

5. Sunlight refracts in the atmosphere as it travels to your eyes. Your brain perceives that light travels in a straight line, creating a perception of an image of the sun on the horizon.



(4 marks)

6. a. Yes, x-rays reflect the same way that light does. When they strike the metal deflector, they reflect such that $\theta_i = \theta_r$. Also, it can be shown by the x-ray photograph that x-rays pass through skin, but reflect off bones, creating an image.



(2 marks)

b. Yes, x-rays propagate the same way that light does.

- They travel in straight lines as shown by the clear shadows of the bones.
- They travel at the same speed that light does, as shown in the following calculation.

$$c = f\lambda \qquad c = f\lambda$$
$$= \left(4.0\times10^{18}\ \text{Hz}\right)\left(7.5\times10^{-11}\ \text{m}\right) \qquad = \left(6.0\times10^{17}\ \text{Hz}\right)\left(5.0\times10^{-10}\ \text{m}\right)$$
$$= 3.0\times10^{8}\ \text{m/s} \qquad = 3.0\times10^{8}\ \text{m/s}$$

(4 marks)

Section 3: Making Choices/Reducing Risks

Key Concepts

- Risk is the hazard associated with an activity.
- Every activity has some risk associated with it.
- Experts assess risk by gathering data about an activity and producing statistics indicating the amount of risk from this data.
- The general public assesses risk by forming a risk perception using criteria such as potential for catastrophe, degree of control, and knowledge of the hazard.
- Activities that the public is familiar with are usually deemed to have a lower risk than activities that are not familiar even if statistics are available to indicate otherwise.
- You can better assess the degree of risk of an activity if you gather as much factual information about the activity as you can.
- Assess both the risks and the benefits of the activity and draw a conclusion by weighing each of these risks and benefits.

Teaching Suggestions

This section enables students to synthesize much of what they've learned in this module with previous studies in science to develop a position on the issue of suntanning. At first students may see this issue as a red herring, but valuable comparisons can be made to attitudes toward cigarette smoking in the 1940s and 1950s. This comparison is presented in detail as one of the Enrichment activities and it may help students to see that it is possible for a fashion trend to have enormous health implications for the whole population.

The section begins by introducing students to the differing ideas of risk perception and risk assessment. One theme that runs throughout this section is that since the process of producing a risk assessment is so very different from the process of forming a risk perception, the outcomes of these approaches are often quite divergent. Students should be encouraged to see the value in both approaches and to understand the importance of dialogue between those that hold conflicting views.

Section 3: Assignment Answer Key (30 marks)

1. The following chart best answers this question.

	Risk Assessment	Risk Perception
Who does this?	experts	members of the general public
How is this done?	statistical analysis	thinking about factors that influence the perception of risk
What is produced?	a statistical assessment of risk	a judgement in the mind of the person

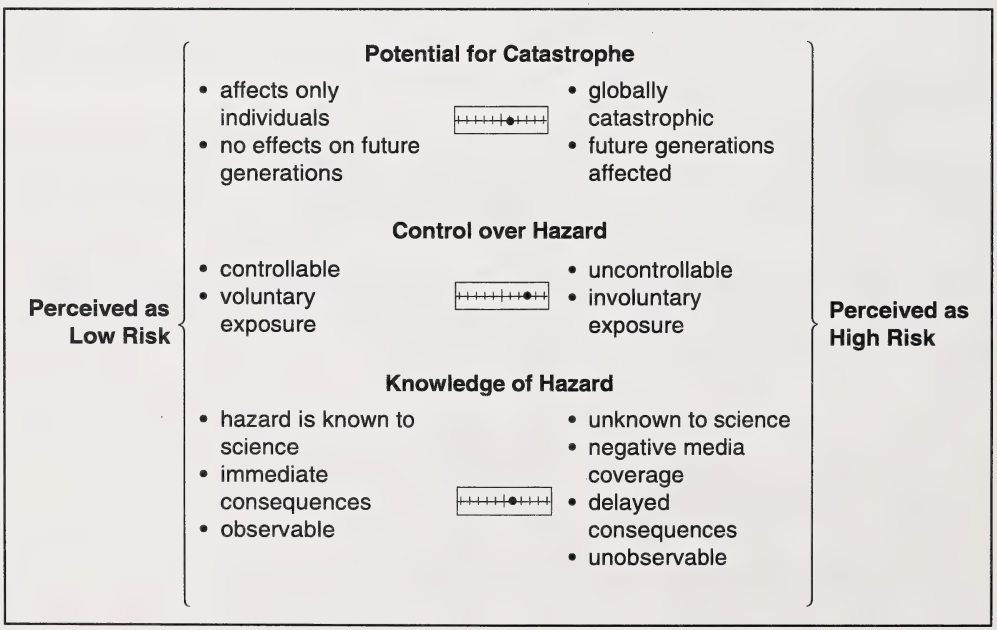
Note: An answer in paragraph form is acceptable if it contains similar information to that presented in the chart. **(3 marks)**

2. Students should choose **two** of the following:

   - This statistic is beyond the limit of understanding for most people, since anything smaller than 1 in 10 000 becomes meaningless.
   - If their opinion is based on a risk perception, there may be a significant sense of dread due to the potential for catastrophe, the lack of control over the hazard, and the lack of knowledge of the hazard. This perception of dread is unlikely to change due to one statistic.
   - Deeply held opinions are very difficult to change.
   - The level of suspicion and mistrust of the experts by some members of society may detract from their willingness to accept this statistic as being valid.

(3 marks)

3. a. The following answers provide one example of many possibilities.



(3 marks for positions of dots on the continua)

b. Flying as a passenger in a commercial airliner has a great potential for catastrophe since hundreds of people can be killed in a very short time. These types of accidents also give the passenger little chance of controlling the outcome because the accidents usually involve the whole aircraft falling to the ground. Although the hazard is known and is observable, negative media coverage of crash sites has left a deep, negative impression on many people. **(3 marks)**

4. Answers will vary. Paragraphs should include a statement of the position the student has chosen, at least two reasons supporting the position, as well as a concluding statement. In the analysis, reasons such as "My grandfather smoked all his life and he lived until he was ninety" and "Suntanning makes a person look healthy" would fall under the risk perception category. Reasons such as "Smoking can be associated with 97 200 deaths in Canada each year" and "There will be 47 000 new cases of skin cancer in Canada this year" would fall under risk assessment category. **(6 marks total; 2 marks for communication)**

5. a. In the evening the cross section of atmosphere that the UV rays must penetrate is much thicker than it is earlier in the day. This means that fewer UV rays reach the surface of Earth in the evening than in the afternoon. Because it is the UV rays that damage skin cells, there will be more damage done in the afternoon than in the evening. **(3 marks)**

b. At high altitudes there is less atmosphere above to absorb the ultraviolet rays of the sun than at sea level, thereby allowing more ultraviolet rays to strike the people living there. **(2 marks)**

c. The ultraviolet rays from the sun are absorbed at a much higher altitude over City B than they are over City C. This is due to the fact that the UV rays over City B strike nearly parallel to the curve of Earth and the atmosphere, while over City C the rays strike in a more perpendicular direction. **(2 marks)**

d. The hours prior to sunset involve the UV rays of the sun bombarding the upper parts of the atmosphere which raises the reflective ceiling of the ionosphere. AM radio waves can reflect off this boundary. If the area of strongest reflection is higher, then the range of reception is extended. City A would be enjoying the high reflective ceiling that would tend to linger over their city since sunset had just passed. City C has the reflective ceiling much lower so this would reduce the range of reception. **(3 marks)**

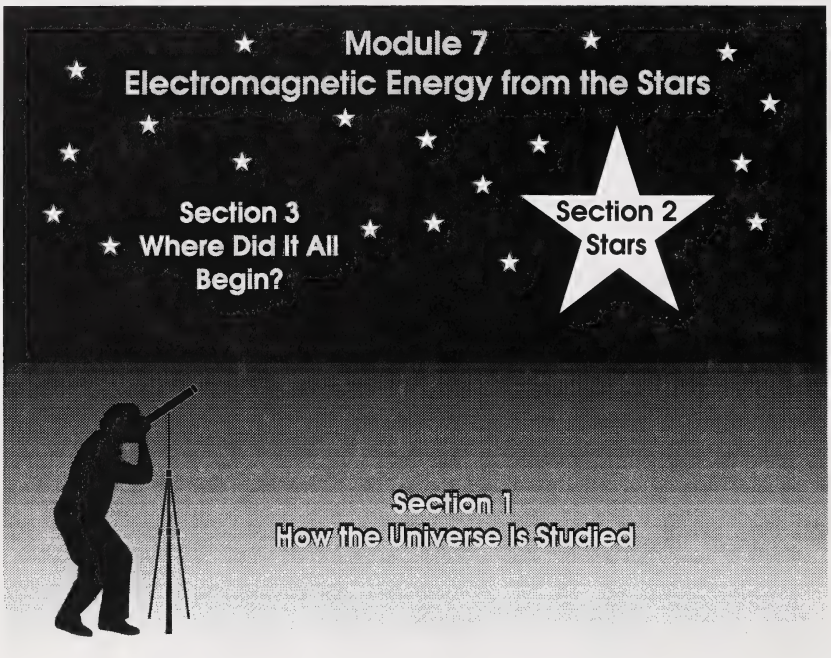
e. FM radio waves do not reflect off the ionosphere in the same way, so there is no reflective ceiling in this case to extend the range of the broadcast. **(2 marks)**

Module 7: Electromagnetic Energy from the Stars

Overview

This module introduces students to some of the theories and technologies involved in the science of astronomy. In Section 1 the universe is analysed in terms of the properties of reflection and refraction, as well as diffraction and interference. Spectral fingerprinting is also introduced as a major tool used in the study of the universe. Section 2 analyses the property of colour and the information about the universe that can be obtained from the colour of the stars and galaxies. Section 3 hypothesizes about the beginning of the universe and analyses some of the methods used to formulate theories on the formation and future of the universe.

A number of investigations are provided to enhance the development of science process skills. STS connections are reinforced by reference to the latest NASA space exploration programs. Students should be encouraged to discuss and analyse present space programs in terms of costs and benefits.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**30 marks**
Section 2 Assignment	**45 marks**
Section 3 Assignment	**25 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

The following is a list of materials and equipment necessary for an individual to complete the investigations and activities in Module 7. Adjust the amount of equipment if more than one individual is involved.

Section 1: Activity 3

- tape
- showcase light bulb and socket
- ruler
- blue and red filters
- diffraction grating (diameter of slit = 1.88×10^{-6} m or 5315 lines/cm)

Section 1: Activity 4

- diffraction grating (same as Activity 3)
- shoe box
- scissors
- tape

Optional Videos

Section 1, Activity 2

NASA Space: New Universe, ACCESS Network.

Section 3, Activity 2

NASA Space: Universe, ACCESS Network.

Other videos which may be used with this module are as follows:

A Galactic Encyclopedia: In the Beginning, Marlin Motion Pictures, 1993.

A Galactic Encyclopedia: Eyes of the Universe, Marlin Motion Pictures, 1993.

A Galactic Encyclopedia: Introductory Space, The Future, Marlin Motion Pictures, 1993.

A Galactic Encyclopedia: Lives of the Stars, Marlin Motion Pictures, 1993.

The video series, *A Galactic Encyclopedia*, is distributed in Canada by Marlin Motion Pictures, 211 Watline Ave., Mississauga, Ontario, L4Z 1P3.

Additional Resources

Alberta Education. 1994. Science 30 Resource Manual. Edmonton, Alberta: Department of Education, Curriculum Branch.

Ferris, Timothy. 1988. *Coming of Age in the Milky Way*. New York: William Morrow and Company, Inc.

Friedman, Herbert. 1990. *The Astronomer's Universe: Stars, Galaxies, and Cosmos*. New York: W. W. Norton & Company.

Hawking, Stephen. 1988. *A Brief History of Time: From the Big Bang to Black Holes*. New York: Bantam Books.

Krisciunas, Kevin. 1988. *Astronomical Centers of the World*. Cambridge, MA: Cambridge University Press.

Malin, David, and Paul Murdin. 1984. *Colours of the Stars*. Melbourne, Australia: Cambridge University Press.

Section 1: How the Universe Is Studied

Key Concepts

- The properties of reflection, refraction, diffraction, and interference are used to reveal much about the universe.
- Initially only visible light was used to study the universe but with the development of new technologies, the entire electromagnetic spectrum is now used to study the universe.
- Colour is used to analyse the stars and the galaxies through spectral fingerprinting.
- The composition of a star can be determined on the basis of the emission or absorption spectra produced.

Section 1: Assignment Answer Key (30 marks)

1. $\Delta d = v\Delta t$

$= \left(3.00\times10^{8}\ \frac{\text{m}}{\text{s}}\right)(500\ \text{s})$

$= 1.50\times10^{11}\ \text{m}$

The distance to the sun is 1.50×10^{11} m. **(2 marks)**

2. $\dfrac{1\ \text{light-year}}{9.46\times10^{15}\ \text{m}} = \dfrac{26.0\ \text{light-year}}{\Delta d}$

$\Delta d = 2.46\times10^{17}\ \text{m}$

The distance to Vega is 2.46×10^{17} m. **(2 marks)**

3. Calculations show that even our fastest probe would take 112 000 years to reach there. Therefore, travel to Alpha Centauri by any known means is impossible. **(2 marks)**

4. a. Radio: on Earth; Dominion Radio Astrophysical Observatory. **(1 mark)**

   b. Infrared: on Earth; UK Infrared Telescope in Hawaii. **(1 mark)**

   c. Visible: on Earth; Mauna Kea, Keck. in Space; Hubble Telescope. **(1 mark)**

   d. Ultraviolet: 70 km above Earth; International UV Explorer. **(1 mark)**

   e. X-rays: more than 60 km above Earth; Advanced X-Ray Astrophysics Facility. **(1 mark)**

   f. Gamma Rays: more than 30 km above Earth; Gamma Ray Observatory. **(1 mark)**

5. a. proved existence of neutron stars, black holes, and mapped the shape of our galaxy **(1 mark)**

   b. pinpoints infant stars, dust in our galaxy **(1 mark)**

   c. indicates location, brightness, and topography of stellar objects **(1 mark)**

   d. used to study stars hotter than our sun **(1 mark)**

   e. proved the existence of black holes **(1 mark)**

   f. helps to locate supernovae, pulsars, neutron stars, and black holes **(1 mark)**

6. a. helium, sodium, and hydrogen **(3 marks)**

   b. It is an emission spectra. **(1 mark)**

   c. These elements are located on the surface of the star. **(2 marks)**

7. a. Propagation reveals the distance to the stars. **(1 mark)**

   b. Reflection and refraction reveal brightness, location, and topography of stellar objects. **(1 mark)**

   c. Interference and diffraction reveal chemical composition. **(1 mark)**

8. a. Infrared radiation shows the dust in our galaxy best because dust is usually relatively cool. **(2 marks)**

   b. Infrared radiation helps to pinpoint infant stars. **(1 mark)**

Section 2: Stars

Key Concepts

- Incandescent objects change colour as temperature changes.
- Colour is an indication of the surface temperature of a star and can be used to classify stars.
- A star's brightness depends on its luminosity and its distance from Earth.
- A star follows a particular life cycle from interstellar nebulae, to a main sequence star, to a red giant, to a white dwarf, a neutron star, a pulsar, or a black hole.
- The life cycle of a star depends on its initial mass.
- The sun and all stars depend on nuclear reactions as an energy source.

Section 2: Assignment Answer Key (45 marks)

1. a. $$\frac{1\ M_{\odot}}{1.99\times10^{30}\ \text{kg}} = \frac{7.00\ M_{\odot}}{m}$$

$$m = 1.39\times10^{31}\ \text{kg}$$

The mass of the star is 1.39×10^{31} kg. **(2 marks)**

b. $$\frac{1\ \text{light year}}{9.46\times10^{15}\ \text{m}} = \frac{5.00\ \text{light years}}{\Delta d}$$

$$\Delta d = 4.73\times10^{16}\ \text{m}$$

The distance to the star is 4.73×10^{16} m. **(2 marks)**

c. $$\frac{1\ \text{AU}}{1.50\times10^{11}\ \text{m}} = \frac{6.00\ \text{AU}}{\Delta d}$$

$$\Delta d = 9.00\times10^{11}\ \text{m}$$

The size of the star is 9.00×10^{11} m. **(2 marks)**

d. The colour indicates the surface temperature and the position on the main sequence of stars. **(2 marks)**

e. The temperature of this star is between 28 000 K and 50 000 K. **(2 marks)**

f. It will be shorter because in larger stars the fusion reactions occur more quickly and consume the fuel faster. **(2 marks)**

g. It will become a neutron star because its mass was more than $M_{\odot}$. **(2 marks)**

2. The initial source of energy at this beginning stage is gravitational potential energy. **(1 mark)**

3. a. The fusion is proton-proton chain or H (hydrogen) to He (helium) fusion. **(1 mark)**

b. **Step 1**

$$^{1}_{1}\text{H} + {}^{1}_{1}\text{H} \rightarrow {}^{2}_{1}\text{H} + {}^{0}_{+1}\text{e} + \nu$$

hydrogen hydrogen deuteron positron neutrino

Step 2

$$^{2}_{1}\text{H} + {}^{1}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He} + \gamma$$

deuteron hydrogen light helium gamma radiation

Step 3

$$^{3}_{2}\text{He} + {}^{3}_{2}\text{He} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{1}\text{H} + {}^{1}_{1}\text{H}$$

light helium light helium helium hydrogen hydrogen

(4 marks; 2 marks for Step 1, 1 mark each for Steps 2 and 3)

c. $\Delta m = \frac{\Delta E}{c^2}$

$$= \frac{4.21 \times 10^{-11}\ \text{J}}{\left(3.00 \times 10^{8}\ \frac{\text{m}}{\text{s}}\right)^2}$$

$$= 4.68 \times 10^{-28}\ \text{kg}$$

The amount of mass lost is 4.68×10^{-28} kg. **(3 marks)**

4. a. A **(1 mark)**

   b. C **(1 mark)**

   c. A **(1 mark)**

   d. When the fuel in the core is gone for the H to He fusion reaction, the star collapses increasing its core temperature while the outer gaseous layer of the star expands and cools. The star now becomes a red giant. **(2 marks)**

5. Heavier atoms of carbon and silicon begin to fuse. **(2 marks)**

6. a. The final form of a star depends on its remaining mass after all fusion stops. **(1 mark)**

   b. If the remaining mass is less than 1.4 $M_{\odot}$, the star will become a white dwarf. **(1 mark)**

   c. If the remaining mass is more than 1.4 $M_{\odot}$, the star will become a neutron star. **(1 mark)**

   d. If the remaining mass is more than 3 $M_{\odot}$, the star will become a black hole. **(1 mark)**

7. a. Novae are formed from double stars (a white dwarf and a red giant existing as a pair). Matter from the red giant is drawn to a white dwarf which causes the white dwarf to flare briefly as a nova. **(3 marks)**

   b. Supernovae are caused when gravitational forces on a star are so strong that electrons and protons combine to form neutrons resulting in a violent explosion called a supernova. **(3 marks)**

8. Neutron stars are made up of neutrons which can be packed much more closely than protons or electrons. This makes the neutron star more dense. **(2 marks)**

9. Interstellar dust → Main Sequence Star → Red Giant → Supernova → Neutron Star → Black Hole **(3 marks)**

Section 3: Where Did It All Begin?

Key Concepts

- The Doppler effect indicates whether an object is travelling toward or away from you.
- The Doppler effect has played an important part in the formation of theories of the universe.
- An approximate age for the universe has been determined using an average value for the Hubble constant.
- Numerous theories for the formation of the universe have been proposed.
- The universe is known to be expanding at the present time, but there is much speculation as to its final outcome.

Section 3: Assignment Answer Key (25 marks)

1. a. $\Delta d = 7.80\times10^{7}$ light years $\times 9.46\times10^{15}\ \frac{\text{m}}{\text{light-year}}$
$= 7.3788\times10^{23}$ m

$v = 1200\ \frac{\text{km}}{\text{s}}$
$= 1.2\times10^{6}\ \frac{\text{m}}{\text{s}}$

$t = \frac{\Delta d}{v}$
$= \frac{7.3788\times10^{23}\ \text{m}}{1.2\times10^{6}\ \frac{\text{m}}{\text{s}}}$
$= 6.1\times10^{17}$ s or 1.9×10^{10} a

The age based on the closest galaxy chosen is 1.9×10^{10} a. **(3 marks)**

b. $\Delta d = 3.96\times10^{10}$ light years $\times 9.46\times10^{15}\ \frac{\text{m}}{\text{light years}}$
$= 3.7462\times10^{26}$ m

$v = 6.1\times10^{7}\ \frac{\text{m}}{\text{s}}$

$t = \frac{\Delta d}{v}$
$= \frac{3.7462\times10^{26}\ \text{m}}{6.1\times10^{7}\ \frac{\text{m}}{\text{s}}}$
$= 6.1\times10^{18}$ s or 1.9×10^{11} a

The age based on the furthest galaxy chosen is 1.9×10^{11} a. **(3 marks)**

c. The average age is 1.0×10^{11} years. The average age as calculated by scientists is 1.5×10^{10} years. The calculated average is reasonably close. **(2 marks)**

2.

Theory of the Creation of the Universe	Is the Universe Expanding or Contracting?	What Is Happening to Matter in the Universe?	How Do Radio Waves Prove or Disprove Each Theory?
Steady-State Theory	It is expanding.	Matter is constantly being created.	There are fewer radio waves as you go farther out meaning matter in the universe is not constant and therefore refutes the theory.
Big-Bang Theory	It is expanding.	Matter is constant so it is becoming less dense.	Weak radio waves emanating from all directions support this theory.

(6 marks)

3. a. The closed universe theory predicts that the universe will stop expanding and eventually contract back to a point in space. **(2 marks)**

b. The open universe theory predicts that the universe will continue to expand forever. **(2 marks)**

c. The major factor that will determine whether the universe is open or closed is the total amount of matter in the universe. **(1 mark)**

4. No, the current theory suggests that every galaxy is moving away from every other galaxy. Therefore, every position in the universe can be considered the centre. **(2 marks)**

5. The supporting evidence necessary to prove the closed theory of the universe is whether there is enough matter in the universe to create the gravitational forces needed to cause an eventual contraction. **(2 marks)**

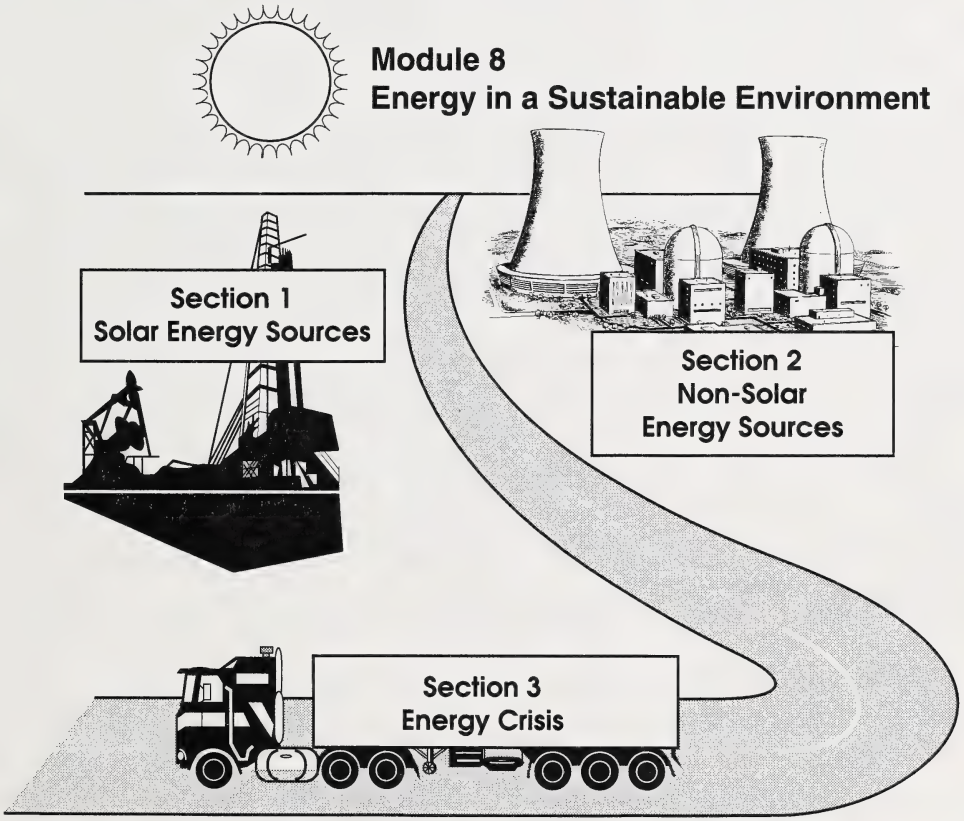
6. The Doppler effect indicates whether the universe is expanding or contracting by a redshift or a blueshift. If a star or galaxy is moving away from Earth there is a shift toward the red end of the visible spectrum. If a star or galaxy is moving toward Earth, there would be a shift toward the blue end of the visible spectrum. **(2 marks)**

Module 8: Energy in a Sustainable Environment

Overview

This module has two related parts. The first part includes Sections 1 and 2, which deal with all known sources of energy. Section 1 identifies various solar energy sources, both non-renewable and renewable. Section 2 explores several non-solar energy sources including nuclear energy, geothermal energy, and tidal energy.

The second part deals with the energy crisis and the attempts to reach sustainable development by analysing several problems and solutions to energy consumption. The STS connections attempt to connect the science in this module to everyday living.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**40 marks**
Section 2 Assignment	**30 marks**
Section 3 Assignment	**30 marks**
TOTAL	**100 marks**

Evaluation Suggestion

In each set of assignment answers there may be one or more answers where the teacher will grade written communication skills. This is clearly indicated in the total possible marks for the question. Use the following guideline for evaluating students' written responses.

Communication (2 marks)

Score	Scoring Descriptions
(2) Excellent	The response communicates the concepts clearly and logically, demonstrating internal consistency of thought. Linkages between cause-and-effect relationships are shown and clearly expressed. Complete sentences that make effective use of scientific vocabulary are used. If applicable, suitable diagrams/sketches are used to illustrate the verbal descriptions. The response addresses the major points of the question.
(1) Satisfactory	The response may require more than one reading to abstract the sense. Linkages between cause-and-effect relationships are shown. Some internal inconsistency of thought is evident. Some scientific vocabulary is used. The response addresses some of the major points of the question.
(0) Unacceptable	The response shows little evidence of internal consistency of thought. The communication is muddled because of inappropriate vocabulary and incomplete sentence structure. The length of the response is inadequate to address even one of the major points of the question.

Materials and Equipment

Section 1: Activity 2

Investigation: Photovoltaic Cells

- centimetre ruler
- multimeter (Wavetek, DM2XL)
- 1 photovoltaic cell (200 mA, 2 W)
- 2 connecting leads with alligator clips
- green and blue filters
- 1 pair of sunglasses

Section 1: Activity 3

Investigation: Determining the Heat Energy Experimentally

Part A

- matches
- candle
- balance
- glass beaker
- retort stand and clamp
- thermometer and clamp
- stirring rod
- 100 g of water

Part B

- Data results from Part A in Appendix

Section 3: Activity 3

Investigation: Designing an Energy Efficient Hot Water Heater

Part A

Materials will vary. This is an investigation in which students are to choose equipment to suit their design.

Part B

- pencil and paper

Additional Resources

Anderson, Bruce. *The Fuel Savers: a Kit of Solar Ideas for Your Home, Apartment, or Business.* Lafayette, CA: Morning Sun, 1991.

Clark, Bob. *Tidal Power and Canada: A Review.* Efficiency and Alternative Energy Technology Branch of Energy, Mines and Resources Canada, Cat. No. M91–7/16–1988E. Ottawa: Minister of Supply and Services Canada, 1988.

Close, Frank. *Too Hot to Handle: The Story of the Race for Cold Fusion.* London, England: W.H. Allen Publishers, 1990.

Energy, Mines and Resources. Canada, Ottawa. *Community Energy Planner*

Hafele, Wolf. "Energy from Nuclear Power," *Scientific American.* New York: September, 1990.

Hamakawa, Yoshihiro. "Photovoltaic Power," *Scientific American*, Vol. 256, No. 4, April 1987.

Karfman, Donald G. and Cecilia M. Franz. *Biosphere 2000: Protecting Our Global Environment.* New York: Harper Collins College Publishers, 1993.

Mallove, Eugene F. *Fire from Ice: Searching for the Truth Behind the Cold Fusion Furor.* New York: John Wiley and Sons, Inc., 1991.

McCutcheon, Sean. *Exploring Energy 2: Bioenergy.* Ottawa: Minister of Supply and Services, 1984.

McCutcheon, Sean. *Exploring Energy 3: Geothermal Energy*, Energy, Mines and Resources Canada, Cat. No. NR53–2/3–1984E. Ottawa: Minister of Supply and Services, 1983.

Miller, Peter. "A Comeback for Nuclear Power?" *National Geographic Magazine*, Vol. 180, No. 2, August 1991, pp. 6–89. Washington, D.C.: National Geographic Society.

Patterson, Walter. *The Energy Alternative.* London: Boxtree Books, 1990.

Robertson, J.A.L. *Nuclear Energy in Canada: The CANDU System*, Atomic Energy of Canada Ltd., AECL-6328 (Rev. 2). Ottawa: 1990.

Zwicky, Lynn. *Energy Conservation: A Goal for Albertans?* ECA88-PA/CS-S5, Environment Council of Alberta. Edmonton: Alberta Department of Energy, 1988.

Mandatory Videos

Section 2, Activity 1

Nuclear Physics: *The Discovery of Radioactivity*, TVOntario. ACCESS Network.

Nuclear Physics: *The Properties of Becquerel Rays*, TVOntario. ACCESS Network.

Nuclear Physics: *Natural Transmutations*, TVOntario. ACCESS Network.

Optional Videos

Nuclear Power, Classroom Video, 1993, Unit C, 9005 Centaurus Circle, Burnaby, British Columbia, V3J 7N4.

Other Videos

The following videos may be used with Module 8.

- *The Science of Energy*, MediCinema Ltd., 1994.
- *Energy Choices*, MediCinema Ltd., 1995.

The preceding videos may be purchased from

MediCinema Ltd.
131 Albany Ave.
Toronto, Ontario
M5R 3C4

Laser Disk

Nova: Back to Chernobyl, WGBH Education Foundation, Western CineVision, 1989.

This laser disk is distributed by Image Entertainment Inc.

Section 1: Solar Energy Sources

Key Concepts

- Energy is the sustaining factor of all activity in the universe.
- Much of the energy used today can be attributed to the sun.
- Solar energy can be classified as renewable and non-renewable.
- Solar energy can be used directly (solar cells) or indirectly (wind, hydro, biomass, fossil fuels).
- The amount of energy per mole released by fossil fuels can be calculated.

Teaching Suggestions

This section deals with all the energy sources related to solar energy. Students should have no difficulty except when it comes to the calculations of heats of reaction. It is important to follow the steps in the example problems.

Section 1: Assignment Answer Key (40 marks)

1. C **(1 mark)**

2. B **(1 mark)**

3. a. i. This part should be an insulating material, like wood or wood with insulation, so that no thermal energy escapes. **(2 marks)**

ii. This part should be a good absorber of radiant energy like black tiles which would absorb all the sun's energy and re-emit it as thermal energy inside the box. **(2 marks)**

iii. This part should be a good heat-absorbing fluid like antifreeze, which would absorb the thermal energy inside the box and transport it to an external device which uses or stores this energy. **(2 marks)**

iv. This part should be a material, like glass, that allows light energy in but will not allow heat energy out. **(2 marks)**

b. This is an active solar collector because it uses a device to circulate the trapped heat energy. **(2 marks)**

c. Radiant solar energy would be converted to thermal energy in the box. **(2 marks)**

d. When radiant solar energy enters the box and is absorbed, it is re-emitted as thermal energy of a longer wavelength which cannot radiate back through the glass. **(2 marks)**

4. a. The sun's radiant energy strikes water causing evaporation which starts the hydrological cycle. When the moisture comes back down as rain, it flows into rivers which may then be used for generating electricity. **(2 marks)**

b. Solar energy → thermal energy (heats water causing evaporation) → potential and kinetic energy (causing moving water in hydrological cycle) → kinetic energy (moving water in rivers) → mechanical energy (turning turbines) → electrical energy (generator) **(3 marks)**

5. a. Solar energy is being converted to electrical energy. **(1 mark)**

b. The layers must gain opposite charges so that an electric field can be created in the photocell which will cause "freed" electrons to move in a certain direction creating a current. The doping by different elements causes one layer to gain a net negative charge and the other layer to gain a net positive charge. **(3 marks)**

6. Fossil fuels originate from plants and microorganisms which relied on the energy from the sun to produce their food through photosynthesis. These plants or organic material were in the form of biomass millions of years ago. **(2 marks)**

7. a. If a ΔH_r° is positive, then it is an endothermic reaction and heat is required to make the reaction proceed. If a ΔH_r° is negative, then it is an exothermic reaction and heat energy is released by the reaction. **(2 marks)**

b. The heat of formation of a substance is defined as the change in heat content when it is formed from its elements. The heat of formation of an element is defined as zero since there would be no heat change if an element were prepared from itself. **(2 marks)**

8. $CH_{4(g)} + 2\,O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(g)}$ **(2 marks)**

9. a. $\Delta H_r^\circ = \Sigma \Delta H_f^\circ \text{ products} - \Sigma \Delta H_f^\circ \text{ reactants}$

$$= \Delta H_f^\circ \left[16\,CO_{2(g)} + 18\,H_2O_{(g)}\right] - \Delta H_f^\circ \left[2\,C_8H_{18(g)}\right]$$

$$= \left[16 \text{ mol}(-393.5 \text{ kJ/mol}) + 18 \text{ mol}(-241.8 \text{ kJ/mol})\right] - \left[2 \text{ mol}(-250.1 \text{ kJ/mol})\right]$$

$$= \left[-6296 \text{ kJ} + (-4352.4 \text{ kJ})\right] - \left[-500.2 \text{ kJ}\right]$$

$$= \left[-10\,648.4 \text{ kJ}\right] - \left[-500.2 \text{ kJ}\right]$$

$$= 1.0148 \times 10^4 \text{ kJ} \quad \left(\text{for 2 mol } C_8H_{18(l)}\right)$$

$$= 5.07 \times 10^3 \text{ kJ/mol}$$

The heat of combustion is 5.07×10^3 kJ/mol. **(4 marks)**

b. Find the number of moles of C_8H_{18}.

1 mole of $C_8H_{18} = 114.26$ g

10.0 g of C_8H_{18} is $\frac{1 \text{ mol}}{114.26 \text{ g}} = \frac{n}{10.0 \text{ g}}$

$= 0.87520$ mol

Find the amount of heat in joules.

If 1 mol C_8H_{18} releases 5.0741×10^3 kJ,

then 0.087520 moles C_8H_{18} releases $0.087520 \text{ moles} \times 5.0741 \times 10^3 \text{ kJ/mole} = 444 \text{ kJ}$

The amount of heat released is 444 kJ. **(3 marks)**

Section 2: Non-Solar Energy Sources

Key Concepts

- Nuclear reactions are the source of large amounts of energy.
- Radioactive substances emit Bequerel rays.
- Three types of Bequerel rays are alpha rays, beta rays, and gamma rays.
- The radioactive decay of one substance into another is termed transmutation.
- Strong nuclear forces hold the nucleus together.
- Nuclear fission is splitting the nucleus into smaller nuclei and energy.
- Nuclear fusion is combining two nuclei together with the release of energy.
- Controlled fission reactions are used in the production of electrical energy.
- In a nuclear reaction some mass is converted to energy. The amount of energy can be calculated using the formula $E = mc^2$.
- Other non-solar energy forms are geothermal energy and tidal energy.
- Geothermal energy is the result of heat moving up to the surface from the interior of Earth.
- Tidal energy is that energy which can be used from the cycles of the tides to produce electrical energy.

Teaching Suggestions

This section deals with all the non-solar energy sources including nuclear, geothermal, and tidal energy. The only difficulty will come in the nuclear section, but the videos are excellent as teaching aids and should be used. The calculations of nuclear energy are performed with several examples and should be studied carefully.

Section 2: Assignment Answer Key (30 marks)

1. B **(1 mark)** 2. A **(1 mark)** 3. C **(1 mark)** 4. D **(1 mark)**

5. a. An alpha particle is emitted. **(1 mark)**

   b. A beta particle is emitted. **(1 mark)**

6. a. ${}^{12}_{6}C + {}^{12}_{6}C \rightarrow {}^{24}_{12}Mg + {}^{0}_{0}\gamma$ **(1 mark)**

   b. ${}^{16}_{8}O + {}^{16}_{8}O \rightarrow {}^{28}_{14}Si + {}^{4}_{2}He$ **(1 mark)**

   c. ${}^{207}_{82}Pb \rightarrow {}^{207}_{83}Bi + {}^{0}_{-1}e$ **(1 mark)**

7. a. ${}^{234}_{91}Pa \rightarrow {}^{234}_{92}U + {}^{0}_{-1}e$ **(1 mark)**

b. ${}^{234}_{92}\mathrm{U} \rightarrow {}^{230}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$ **(1 mark)**

c. ${}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{146}_{57}\mathrm{La} + {}^{87}_{35}\mathrm{Br} + 3{}^{1}_{0}\mathrm{n}$ **(1 mark)**

8. Neutrons help a nucleus to be stable. Lighter nuclei have equal numbers of protons and neutrons and tend to be stable. Heavy nuclei have more neutrons than protons and tend to be unstable. After a certain point all nuclei are unstable. **(3 marks)**

9. a. $E = mc^2$ **(2 marks)**

$$= \left(8.47 \times 10^{-27}\ \text{kg}\right)\left(3.00 \times 10^{8}\ \text{m/s}\right)^2$$

$$= 7.62 \times 10^{-10}\ \text{J}$$

b. Alpha radiation is emitted. **(1 mark)**

10. a. ${}^{16}_{8}\mathrm{O} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{20}_{10}\mathrm{Ne} + {}^{0}_{0}\gamma$ **(2 marks)**

b. mass of reactants = mass of ${}^{16}_{8}\mathrm{O}$ + mass ${}^{4}_{2}\mathrm{He}$ **(2 marks)**

$$= \left[\left(15.990\,52 \times 10^{-3}\ \text{kg/mol}\right) + \left(4.001\,50 \times 10^{-3}\ \text{kg/mol}\right)\right]$$

$$= 1.999\,202 \times 10^{-2}\ \text{kg/mol}$$

c. mass of products = mass of ${}^{20}_{10}\mathrm{Ne}$ **(2 marks)**

$$= \left[19.986\,95 \times 10^{-3}\ \text{kg/mol}\right]$$

$$= 1.998\,695 \times 10^{-2}\ \text{kg/mol}$$

d. mass defect = mass of products – mass of reactants **(2 marks)**

$$= 1.998\,695 \times 10^{-2}\ \text{kg/mol} - 1.999\,202 \times 10^{-2}\ \text{kg/mol}$$

$$= -5.07 \times 10^{-6}\ \text{kg/mol}$$

e. $E = mc^2$ **(2 marks)**

$$= \left(5.07 \times 10^{-6}\ \text{kg/mol}\right)\left(3.00 \times 10^{8}\ \text{m/s}\right)^2$$

$$= 4.56 \times 10^{11}\ \text{J/mol}$$

11. The source of geothermal energy at the present time is radioactive decay in Earth's interior. **(1 mark)**

12. The force most responsible is the gravitational force of the moon on Earth's oceans. **(1 mark)**

Section 3: Energy Crisis

Key Concepts

- The amount of energy used globally has increased rapidly in the last seventy-five years.
- Unless there are substantial changes to how fossil fuels are used, this source of energy will run out within the next 50 to 100 years.
- The amount of energy used is not necessarily dependent on population.
- The industrialized countries are the largest users of energy.
- Efficiency in the consumption of current energy resources is only a temporary solution to both the supply and pollution problem.
- Pollution from fossil fuels is a major concern.
- Alternate energy sources need to be developed with possible pollution problems in mind.
- The various sectors of society can do their part to reduce consumption and hence pollution.

Teaching Suggestions

This final section deals with energy—from supply to demand and the risks and benefits associated with each. It is important that students read the textbook extensively in order to answer all the questions successfully.

Section 3: Assignment Answer Key (30 marks)

1. D **(1 mark)** 2. C **(1 mark)** 3. B **(1 mark)**

4. Fossil fuels are readily available throughout the world and most of the technology is in place to exploit and extract this energy source. **(2 marks)**

5. a. Benefits of this change are as follows:

   - more efficient in terms of heat production
   - environmentally cleaner
   - more reserves available
   - less expensive

   (3 marks)

   b. Disadvantages of this change are as follows:

   - still causes pollution (thermal and gases)
   - non-renewable
   - not available everywhere
   - initial cost involved in covnersion

   (3 marks)

6. a. Newer homes have thicker and better insulation. **(1 mark)**

   b. Walls are thicker to hold more insulation. A carefully sealed vapour barrier is now standard. **(1 mark)**

   c. Appliances are more fuel efficient. For example, natural gas furnaces for heating are far more fuel efficient and electrical appliances also consume far less power. **(1 mark)**

7. a. Both biomass and fossil fuels originate from plants or organic material. **(1 mark)**

   b. Biomass is considered a renewable energy source because it is easily replenished. **(1 mark)**

   c. Biomass will not produce pollutants like NO_x or SO_2. **(1 mark)**

8. Canada consumes more energy because it is more industrialized and also because it has a colder climate. **(2 marks)**

9. a. Co-generation is the practice of using waste thermal energy from one process to power a second process. Examples of co-generation include steam produced to generate electricity may also provide steam heating in the building and waste heat from operating equipment may be collected and used to heat the building in which this equipment is located or adjacent buildings. **(2 marks)**

   b. Industry pays for electrical demand according to their maximum usage. Load scheduling is using two machines alternately rather than at the same time where possible to reduce peak electrical demand. **(2 marks)**

10. As these countries become more developed, they will become more industrialized, and therefore will place a huge demand on energy sources. **(2 marks)**

11. Answers will vary, but your home design should include five features from the following:

    - using the maximum amount of insulation and weather stripping
    - installation of a well-sealed vapour barrier
    - installing energy-efficient, heat-reflecting windows
    - aligning the house and installing windows so as to take maximum advantage of the sun's energy
    - large overhang to shade the windows in the summer
    - planting trees to shade the house in the summer but allow sunlight through in the winter.
    - installation of a high efficiency furnace to reduce fuel consumption.
    - use of a programmable thermostat to reduce fuel consumption at night or when the house is unoccupied

    (5 marks)

Final Test

Note: Scientific calculators are recommended when writing this test. A science data booklet is included with this test.

Included here is the answer key to the final test and the student's copy of the final test. The student's copy of the final test is designed for photocopying and faxing.

Note

The answer key and student's copy of this final test should be kept secure by the teacher. Students should not have access to this test until it is assigned in a supervised situation. The answers should be stored securely and retained by the teacher at all times.

SCIENCE 30 FINAL TEST ANSWER KEY

PART A – MULTIPLE CHOICE

1 C	9 A	17 D	25 C	33 A	41 A
2 A	10 C	18 B	26 C	34 B	42 D
3 B	11 D	19 B	27 C	35 D	43 A
4 A	12 A	20 B	28 D	36 C	44 C
5 B	13 C	21 D	29 D	37 D	45 C
6 A	14 B	22 D	30 B	38 D	46 B
7 D	15 C	23 B	31 A	39 B	
8 C	16 B	24 A	32 C	40 D	

PART B – NUMERICAL RESPONSE

1	2	3	4	5	6
4231	0.20	0.25	4411	9.7	9.79

7	8	9	10	11	12
7.03	64	2	4.08	3214	2.00

Part C – Written Response (25 marks)

1. Student answers should be similar to the following points in the order given for full marks.

   - receptors (eyes) see person slip off cliff
   - nerve impulses sent to brain via sensory neurons to process and interpret situation
   - information sent back via motor neurons to initiate a response
   - response includes sending more blood to skeletal muscles
   - to get more blood to skeletal muscles an increase in blood pressure and heart rate must take place
   - messages (neural and hormonal) sent to the heart and blood vessels to increase heart rate and pressure, respectively
   - skeletal muscles contract, lifting person up from cliff
   - nervous system restores equilibrium by returning heartrate to normal and blood pressure to normal

   (6 marks total; $\frac{1}{2}$ mark each for a maximum of 4 marks for concepts, 2 marks for communication)

2. The process of treating hazardous waste at the Alberta Special Waste Treatment plant in Swan Hills is considered to be environmentally sound because of the following treatment and precautions.

   - Incineration of toxic or nonbiodegradable chemicals reduces them to sterile ash which is then sealed into special landfills.
   - Liquids are reduced to a nontoxic form and deposited into very deep wells so that ground water is unaffected.
   - Continuous monitoring is undertaken to check for leaks.

   (3 marks)

3. a. Earth creates a gravitational field that fills the surrounding space. This field allows Earth to exert a force of gravity on objects like the satellite. Even though the gravitational field is only detectable by its effect on masses, it is the invisible connection between Earth and the satellite. **(2 marks)**

   b. $f_1 = 1.5 \times 10^9$ Hz
   $\lambda_1 = ?$
   $f_2 = 1.0 \times 10^{10}$ Hz
   $\lambda_2 = ?$
   $c = 3.00 \times 10^8$ m/s

   (2 marks)

   $c = \lambda f$

   $\lambda = \frac{c}{f}$

   $\lambda_1 = \frac{c}{f_1} = \frac{3.00 \times 10^8 \text{ m/s}}{1.5 \times 10^9 \text{ Hz}} = 0.20 \text{ m}$

   $\lambda_2 = \frac{c}{f_2} = \frac{3.00 \times 10^8 \text{ m/s}}{1.0 \times 10^{10} \text{ Hz}} = 0.030 \text{ m}$

   c. Magnetic fields can only exert forces on magnets or on moving charged particles. Microwaves are a form of electromagnetic radiation; they do not consist of charged particles. It follows that the magnetic field of Earth should not deflect the microwaves. **(2 marks)**

   d. total time = 105 min
   eclipse time = 34 min
   sunlight time = 71 min
   $= 1.18\overline{3}$ h
   eclipse power = 1.7 kW
   sunlight power = 1.7 kW + 3.4 kW
   = 5.1 kW

   (2 marks)

   $P = \frac{E}{t}$

   $E = Pt$

   $= (5.1 \text{ kW})(1.18\overline{3} \text{ h})$

   $= 6.0 \text{ kW} \bullet \text{h}$

4. Answers will vary, but the following represents an answer that a typical student might write.

A student in an industrialized country and a student in a developing country would have different opinions on how society should ensure the development of a sustainable environment in the twenty-first century.

A sustainable environment is one in which the needs of today's society are met without compromising the needs of future generations. This is where the difference in opinion will start. A student in an industrialized society may say there needs to be a reduction in the use of fossil fuels and more money must be spent on pollution control devices. Coal should be replaced by natural gas as a source of fuel for generating power. Cars powered by fossil fuels should be replaced by hydrogen or natural gas powered vehicles or by electric cars.

A student in a developing country may say money must be spent on building factories so the economy can be improved. Money cannot be spent on pollution equipment. A student in an industrialized country will say it will be less expensive in the long term if the proper pollution controls are incorporated now. Money will be saved and the pollution problem that would be created will be reduced.

A student in an industrialized country may say it is of utmost urgency that something be done about pollution now. It may be too late to do something after all the additional pollution from the developing countries is added. A student in a developing country may say that the industrial pollution problem has not been increased. A student in an industrialized society may say society has been creating a pollution problem for years and the problem created must be cleaned up.

Although the concept of sustainable development is an acceptable concept to all, the opinions on how to achieve a sustainable development will vary from individual to individual and from nation to nation. The difference in opinions will be especially evident between industrialized nations and developing nations. **(5 marks total; 2 marks for communication)**

SCIENCE 30

FINAL TEST

GENERAL INSTRUCTIONS

YOU HAVE **TWO AND ONE-HALF** HOURS TO COMPLETE THIS TEST. An additional one-half hour may be allowed if required. Work through the entire test answering the questions you are sure you know. You will then be able to concentrate on the questions of which you are not quite sure.

TOTAL MARKS: 100

PART A: Multiple Choice	46 marks
PART B: Numerical Response	12 marks
PART C: Written Response	22 marks

Note: Scientific calculators are recommended when writing this test.

A Science Data Booklet is included with this test.

SCIENCE 30 FINAL TEST ANSWER SHEET

PART A – MULTIPLE CHOICE

1 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	17 Ⓐ Ⓑ Ⓒ Ⓓ	25 Ⓐ Ⓑ Ⓒ Ⓓ	33 Ⓐ Ⓑ Ⓒ Ⓓ	41 Ⓐ Ⓑ Ⓒ Ⓓ
2 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ	18 Ⓐ Ⓑ Ⓒ Ⓓ	26 Ⓐ Ⓑ Ⓒ Ⓓ	34 Ⓐ Ⓑ Ⓒ Ⓓ	42 Ⓐ Ⓑ Ⓒ Ⓓ
3 Ⓐ Ⓑ Ⓒ Ⓓ	11 Ⓐ Ⓑ Ⓒ Ⓓ	19 Ⓐ Ⓑ Ⓒ Ⓓ	27 Ⓐ Ⓑ Ⓒ Ⓓ	35 Ⓐ Ⓑ Ⓒ Ⓓ	43 Ⓐ Ⓑ Ⓒ Ⓓ
4 Ⓐ Ⓑ Ⓒ Ⓓ	12 Ⓐ Ⓑ Ⓒ Ⓓ	20 Ⓐ Ⓑ Ⓒ Ⓓ	28 Ⓐ Ⓑ Ⓒ Ⓓ	36 Ⓐ Ⓑ Ⓒ Ⓓ	44 Ⓐ Ⓑ Ⓒ Ⓓ
5 Ⓐ Ⓑ Ⓒ Ⓓ	13 Ⓐ Ⓑ Ⓒ Ⓓ	21 Ⓐ Ⓑ Ⓒ Ⓓ	29 Ⓐ Ⓑ Ⓒ Ⓓ	37 Ⓐ Ⓑ Ⓒ Ⓓ	45 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	14 Ⓐ Ⓑ Ⓒ Ⓓ	22 Ⓐ Ⓑ Ⓒ Ⓓ	30 Ⓐ Ⓑ Ⓒ Ⓓ	38 Ⓐ Ⓑ Ⓒ Ⓓ	46 Ⓐ Ⓑ Ⓒ Ⓓ
7 Ⓐ Ⓑ Ⓒ Ⓓ	15 Ⓐ Ⓑ Ⓒ Ⓓ	23 Ⓐ Ⓑ Ⓒ Ⓓ	31 Ⓐ Ⓑ Ⓒ Ⓓ	39 Ⓐ Ⓑ Ⓒ Ⓓ	
8 Ⓐ Ⓑ Ⓒ Ⓓ	16 Ⓐ Ⓑ Ⓒ Ⓓ	24 Ⓐ Ⓑ Ⓒ Ⓓ	32 Ⓐ Ⓑ Ⓒ Ⓓ	40 Ⓐ Ⓑ Ⓒ Ⓓ	

PART B – NUMERICAL RESPONSE

1	2	3	4	5	6
7	8	9	10	11	12

Name of Student _____ Student I.D. # _____

Name of School _____ Date _____

Value

PART A: MULTIPLE CHOICE

46

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully and decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

  Example

  This diploma examination is for the subject of

  A. biology
  B. physics
  C. chemistry
  D. science

  Answer Sheet

  Ⓐ Ⓑ Ⓒ ●

- **Use an HB pencil only.**
- If you wish to change an answer, erase **all** traces of your first answer.
- Each question is worth one mark.
- **Do not turn the page to start the examination until told to do so by the presiding examiner.**

1. Blood leaving the superior vena cava would proceed in which order?

   A. left ventricle → left atrium → lungs → right ventricle → right atrium → rest of body
   B. right ventricle → right atrium → lungs → left ventricle → left atrium → rest of body
   C. left atrium → left ventricle → lungs → right atrium → right ventricle → rest of body
   D. right atrium → right ventricle → lungs → left atrium → left ventricle → rest of body

2. A phenomenon called the Bohr effect occurs when

   A. more oxygen is released in tissues which are metabolizing rapidly
   B. more oxygen is released at the site of the lungs
   C. more oxygen is released in tissues which are metabolizing slowly
   D. less oxygen is released in all tissues

3. White blood cells that are nonspecific killers of foreign invaders are

   A. B cells
   B. phagocytes
   C. killer T cells
   D. helper T cells

4. The major difference between humoral immunity and cellular immunity is that

   A. humoral immunity is nonspecific, whereas cellular immunity is specific for particular antigens
   B. only humoral immunity involves lymphocytes
   C. humoral immunity cannot function on its own; it is always activated by cellular immunity
   D. humoral immunity acts against free-floating antigens, whereas cellular immunity works against foreign invaders

5. A neuron will transmit an impulse when the strength of a stimulus is great enough to reach the

   A. polarization level
   B. threshold level
   C. synapse
   D. axon

6. The offspring of matings between two different true-breeding individuals are called

   A. hybrids
   B. mutants
   C. the P generation
   D. the F_2 generation

7. The hereditary factors which an individual will pass on to its offspring are determined by the

   A. environment
   B. cytoplasm
   C. phenotype
   D. genotype

8. The genotype consists of two identical alleles for a certain trait. This expression of the trait only occurs when the alleles are identical. The genotype is

   A. homozygous dominant
   B. heterozygous dominant
   C. homozygous recessive
   D. heterozygous recessive

9. In keeping with the law of independent assortment, what is it that assorts randomly?

   A. sister chromatids
   B. homologous chromosomes
   C. heterologous chromosomes
   D. different genes on the same chromosome

10. In mitosis, the number of chromosome sets in the daughter cells will be

    A. half the number in the parent cell
    B. twice the number in the parent cell
    C. the same as is in the parent cell
    D. one-fourth the number in the parent cell

11. If the sequence of bases along the DNA is AAGCT, then the complementary sequence of bases on an mRNA strand is

    A. AAGCT
    B. TTCGA
    C. AAGCU
    D. UUCGA

12. Ozone is defined as a pollutant when present

    A. near the ground
    B. in the stratosphere
    C. in space
    D. in lakes

13. Name the Brønsted–Lowry bases in this reaction.

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH^+_{4(aq)} + OH^-_{(aq)}$$

A. water and the ammonium ion
B. ammonia
C. ammonia and the hydroxide ion
D. the hydroxide ion

14. When titrating sodium hydroxide with a 0.100 mol/L sulphuric acid solution, a student used phenolphthalein as an indicator. The colour change expected was

A. yellow to red
B. pink to colourless
C. yellow to pink
D. colourless to yellow

15. The endpoint of a titration occurs when

A. the pH curve levels off
B. the pH of the solution is zero
C. the indicator changes colour
D. a stoichiometric amount of acid and base have been mixed

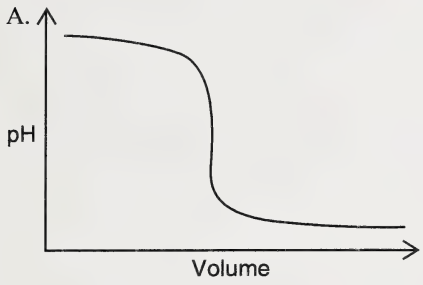
16. Which of the following is a buffer system?

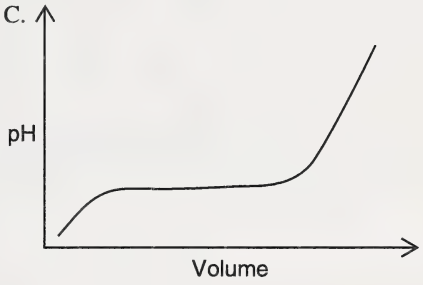
A. $HCl_{(aq)} + NaOH_{(aq)}$
B. $CH_3COOH_{(aq)} + NaCH_3COO_{(aq)}$
C. $HCl_{(aq)} + H_2SO_{4(aq)}$
D. $CH_3COOH_{(aq)} + HCl_{(aq)}$

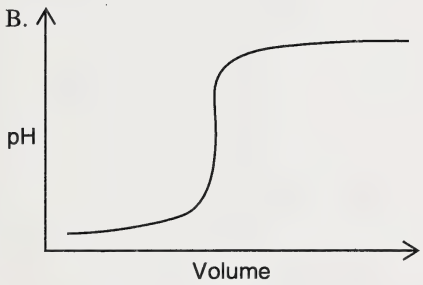
17. If the pH of a solution changes from 5.5 to 2.5, then the hydronium concentration

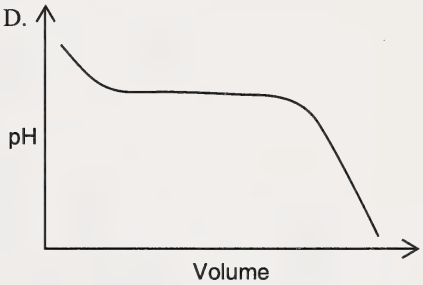
A. dropped by 3 times
B. increased by 3 times
C. dropped by 1000 times
D. increased by 1000 times

18. When a strong acid is titrated by a strong base and a pH curve is drawn, the shape of the curve is

A.


C.


B.


D.


19. Many of the synthetic polymers are formed using an alkene as a monomer. Which of the following molecules could be classified as an alkene?

1. C_6H_{12} 2. C_2H_2 3. C_4H_8 4. C_3H_8

A. 2 and 3 only
B. 1 and 3 only
C. 3 only
D. 4 only

Use the following structural diagrams to answer the next two questions.

1. $CH_3-\overset{\overset{O}{\|}}{C}-CH_3$

2. $CH_3-O-CH_2CH_3$

3. $CH_3CH_2CH_2OH$

4. $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-H$

5. $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-OH$

6. $CH_3-\overset{\overset{O}{\|}}{C}-O-CH_3$

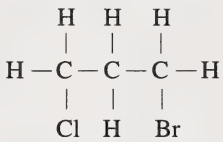
20. The compound that belongs to the alcohol group would be

A. 2
B. 3
C. 4
D. 5

21. The compound that was formed by reacting a carboxylic acid and an alcohol is

A. 2
B. 4
C. 5
D. 6

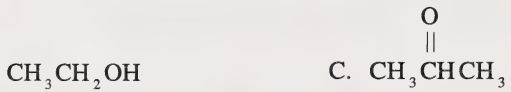
22. The IUPAC name given to the compound shown is



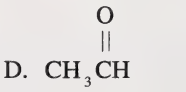
A. chlorobromopropane
B. 1-bromo-1-chloropropane
C. 1,3-dichlorobromopropane
D. 1-bromo-3-chloropropane

23. The toxin isolated from bee stings is capable of turning blue litmus paper red. The most likely compound that is responsible is

A. CH_3CH_2OH



B. $CH-OH$ (with O double-bonded to C)



C. CH_3CHCH_3 (with O double-bonded to the central C)

D. CH_3CH (with O double-bonded to C)

24. The polymer that comprises wood is called

A. lignin
B. cellulose
C. glucose
D. sodium hypochlorite

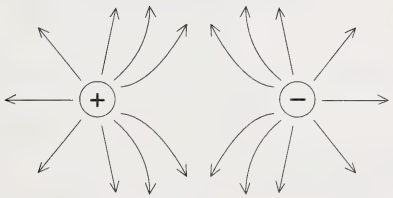
25. Accidental exposure to a contaminated water source results in numbness, loss of vision, and loss of balance. The pollutant responsible is most likely to be

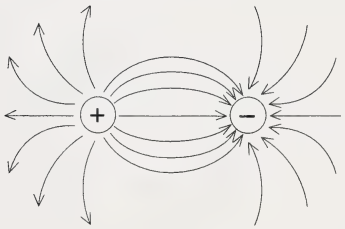
A. lead
B. dioxins
C. mercury
D. PCBs

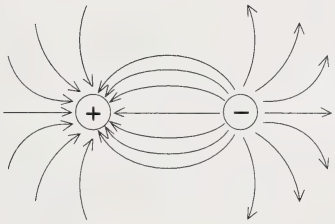
26. Solid hazardous wastes are treated at the Alberta Waste Management Plant in Swan Hills by

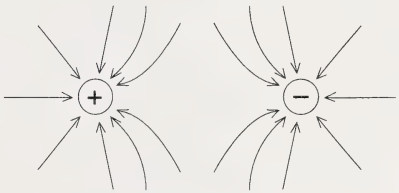
A. stabilizing and storing in deep wells
B. neutralizing and recycling
C. incineration and storage in sealed landfills
D. oxidation and reusing

27. Which of the following correctly shows the direction of the electric field vectors around the two charges?

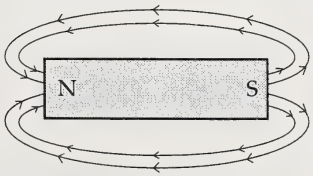
A.


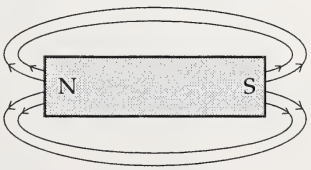
C.


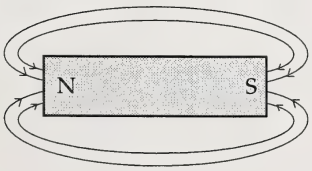
B.


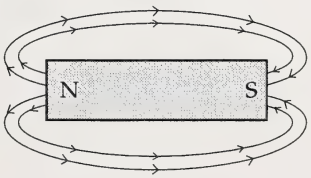
D.


28. Which of the following diagrams shows the direction of the magnetic field around a bar magnet?

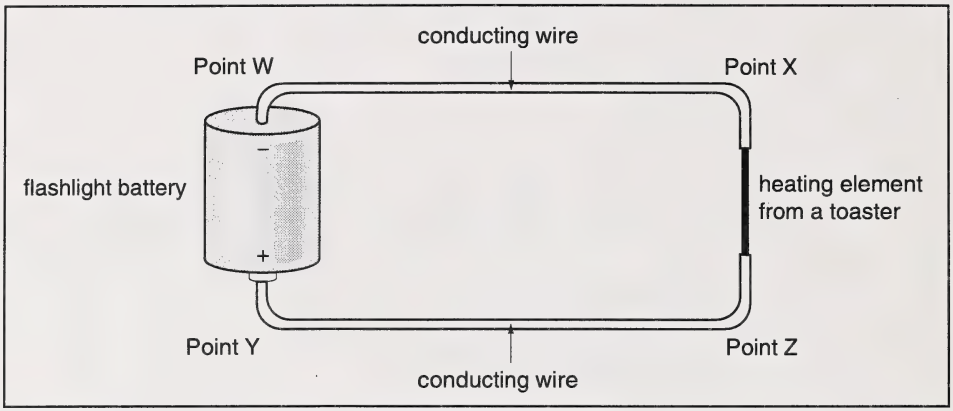
A.


C.


B.


D.


Refer to the following diagram as you answer questions 29 and 30.



29. Between which two points is the potential energy of electrons increased?

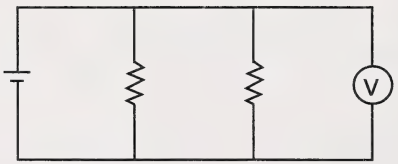
A. W and X
B. X and Z
C. Y and Z
D. W and Y

30. Across which points does the potential difference decrease?

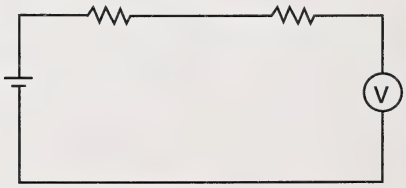
A. W and X
B. X and Z
C. Y and Z
D. W and Y

31. Which of the following schematic diagrams best illustrates how a voltmeter should be connected to measure the potential difference across two resistors connected in parallel?

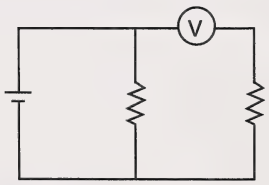
A.



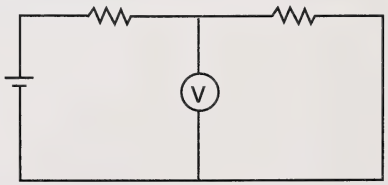
C.



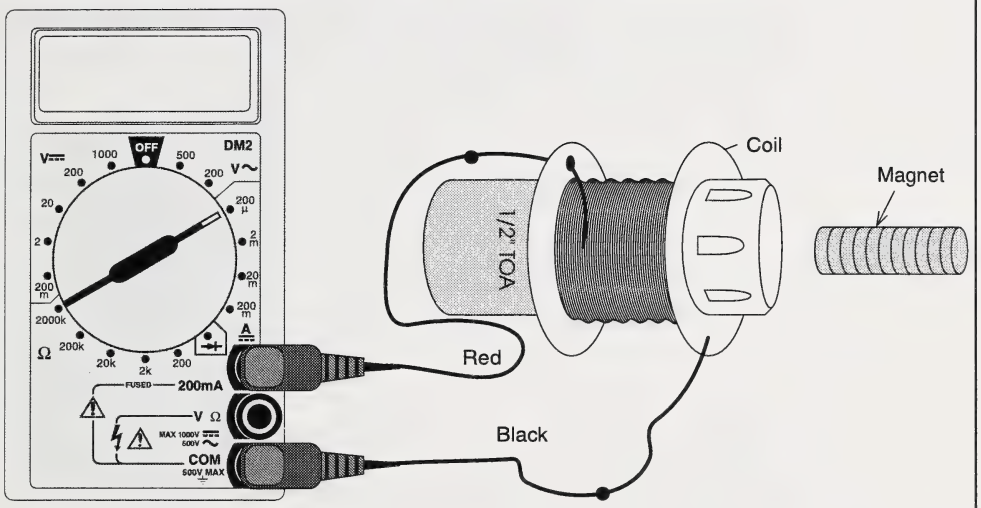
B.



D.



Use the following information to answer the next three questions.



This diagram shows the details of an experiment performed by a student. The student moved the magnet in and out of the coil and watched the reading on the multimeter.

32. Under what circumstances would the student observe a non-zero current reading on the multimeter?

A. when the magnet was held motionless inside the coil
B. when the magnet was held motionless outside the coil
C. when the magnet was quickly pushed into the coil
D. when the magnet was held motionless half inside and half outside the coil

33. The name given to the principle that best explains the operation of the student's experiment is

A. electromagnetic induction
B. motor principle
C. left hand rule for coils
D. left hand rule for force

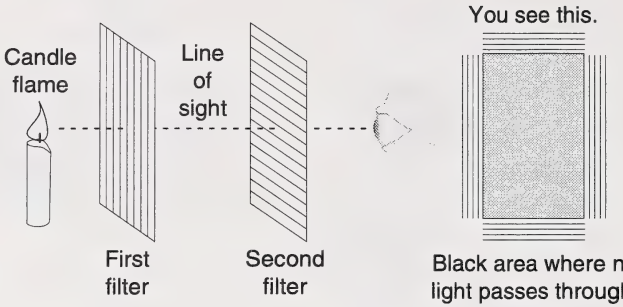
34. Rank the following types of electromagnetic radiation in order from longest wavelength to shortest wavelength.

I gamma rays
II infrared radiation
III radio waves
IV visible light

A. III, IV, II, I
B. III, II, IV, I
C. I, IV, III, II
D. I, II, IV, III

Use the following information to answer the next question.

A student obtained two filters for an experiment. Each filter acting alone would allow you to see an image of the candle flame. However, when the filters were arranged as shown, no image of the candle could be seen.



35. This experiment demonstrates the property of light known as

A. reflection
B. refraction
C. diffraction
D. polarization

36. Which of the following properties of light do telescopes use?

A. colour and dispersion
B. diffraction and interference
C. reflection and refraction
D. propagation and polarization

37. Visible light from stellar objects cannot reveal

A. position of stellar objects
B. brightness of stellar objects
C. topography of stellar objects
D. chemical composition of stellar objects

38. Why can black holes not be directly viewed?

A. They are too small.
B. None are known to exist.
C. Radiation from them cannot penetrate Earth's ozone layer.
D. No radiation is emitted by them.

39. Which of the following is not a fusion reaction occurring on the sun?

A. ${}_{1}^{1}\mathrm{H} + {}_{1}^{1}\mathrm{H} \rightarrow {}_{1}^{2}\mathrm{H} + \nu + {}_{+1}^{0}\mathrm{e}$

B. ${}_{2}^{4}\mathrm{He} \rightarrow {}_{1}^{1}\mathrm{H} + {}_{2}^{3}\mathrm{He}$

C. ${}_{2}^{3}\mathrm{He} + {}_{2}^{3}\mathrm{He} \rightarrow {}_{2}^{4}\mathrm{He} + {}_{1}^{1}\mathrm{H} + {}_{1}^{1}\mathrm{H}$

D. ${}_{1}^{2}\mathrm{H} + {}_{1}^{1}\mathrm{H} \rightarrow {}_{2}^{3}\mathrm{He}$ + gamma radiation

40. The factor that determines whether a star can become a black hole is

A. if the total mass of interstellar dust that formed the star is less than $M_{\odot}$
B. if the total mass of interstellar dust that formed the star is the same as $M_{\odot}$
C. if the total remaining mass after fusion stops is about $1.4\ M_{\odot}$
D. if the total remaining mass after fusion stops is more than $3_{\odot}$

Use the following information to answer the next three questions.

In an experiment to determine the heat produced by the combustion reaction of a candle $C_{25}H_{52(s)}$, the following data was recorded.

mass of candle before = 50.0 g
mass of candle after = 40.0 g

41. Which of the following reactions best denotes the combustion reaction of a candle?

A. paraffin + oxygen → carbon dioxide + water
B. paraffin → sulphur dioxide + carbon dioxide
C. paraffin + oxygen → sulphur dioxide + nitrous oxide
D. paraffin + carbon dioxide → water + heat

42. The heat of combustion of paraffin is

A. -5.43×10^{8} J/mol
B. 1.54 J/mol
C. 0.437 J/mol
D. -1.54×10^{4} J/mol

43. The amount of heat in joules obtained in this experiment is

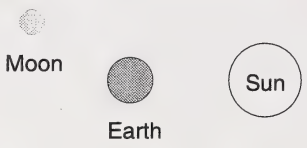
A. 437 J
B. 1.54×10^{-4} J
C. 5.43×10^{8} J
D. 1.54 J

44. Which of the lights shining on a photovoltaic cell will produce the largest current?

A. red light
B. polarized sunlight
C. sunlight
D. blue light

45. The following diagrams show both spring tides and neap tides. Which diagram shows the arrangement that would result in the highest tides?

A.



C.

B.

D.

46. Which path **best** represents the conversion of tidal energy into electrical energy?

A. Solar → kinetic (water) → mechanical → electrical
B. Gravitational potential → kinetic (water) → mechanical → electrical
C. Geothermal → kinetic (water) → mechanical → thermal → electrical
D. Gravitational potential → kinetic (water) → thermal → electrical

Value

12

PART B: NUMERICAL RESPONSE

Instructions

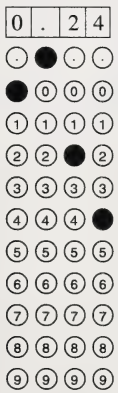
- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**
- Use an HB pencil only.
- If you wish to change an answer, erase **all** traces of your first answer.
- Each question is worth one mark.

Sample Calculation Question and Solution

The mass in kilograms of silver produced when 2.20 mol of silver nitrate reacts with excess copper is _____ kg.
(Record your answer to three digits.)

$$\text{mass}_{Ag} = 0.220 \text{ mol} \times 107.87 \text{ g/mol}$$
$$= 23.7314 \text{ g}$$
$$= 0.24 \text{ kg (recorded to three digits)}$$

Record 0.24 on the answer sheet. →



Sample Correct-order Question and Solution

When the following subjects are arranged in alphabetical order, the order is _____.
(Record all four digits.)

1. mathematics
2. chemistry
3. biology
4. physics

Answer 3, 2, 1, 4

Record 3214 on the answer sheet. →

Start Part B immediately.

1. The following structures illustrate the reflex arc.

   1. effector
   2. spinal cord
   3. motor neuron
   4. sensory neuron

   The proper sequence for these structures is _____, _____, _____, _____.

   RECORD YOUR ANSWER ON THE ANSWER SHEET.

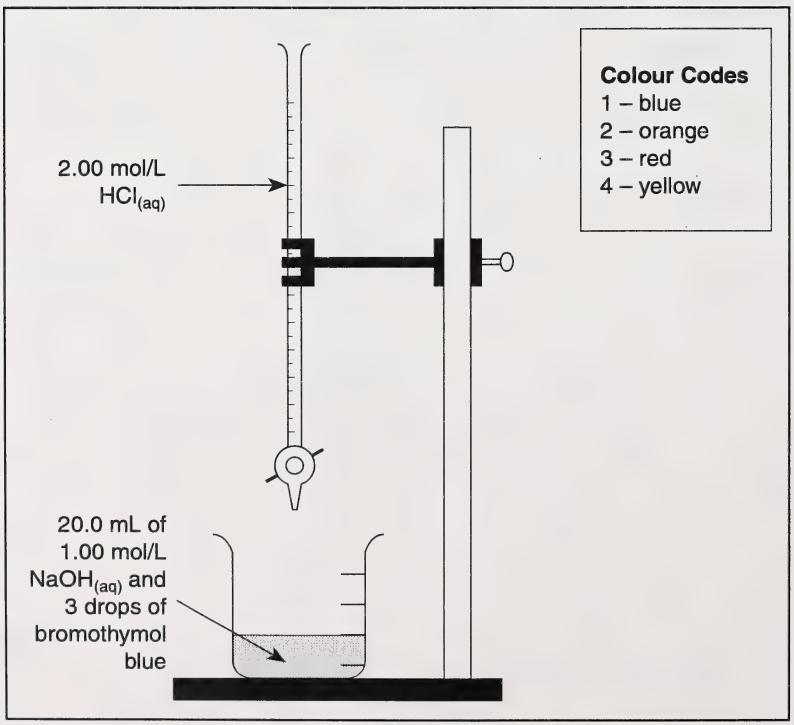
2. In a snail population at Hardy-Weinberg equilibrium, the frequency of the dominant allele for shell colour B (black) is 0.80. The frequency for the recessive allele for shell colour b (yellow) is _____. (Use two significant digits.)

   RECORD YOUR ANSWER ON THE ANSWER SHEET.

3. In watermelons, the allele for green colour is dominant over the allele for striped colour and the allele for short shape is dominant over the allele for long shape. When long, striped watermelons are crossed with dihybrid watermelons, the probability of the offspring being long and green is _____.

   RECORD YOUR ANSWER ON THE ANSWER SHEET.

Use the following diagram and colour-code chart to answer question 4.



4. The code for the colour of the solution in the beaker when

   - no $HCl_{(aq)}$ is added is _____ (Record in first column)
   - 5.0 mL of $HCl_{(aq)}$ are added is _____ (Record in second column)
   - 10.0 mL of $HCl_{(aq)}$ are added is _____ (Record in third column)
   - 15.0 mL of $HCl_{(aq)}$ are added is _____ (Record in fourth column)

   RECORD YOUR ANSWER ON THE ANSWER SHEET.

5. The pH of a solution is 10.0. If the hydronium concentration is doubled, the new pH is _____. (Record your answer to 2 significant digits.)

   RECORD YOUR ANSWER ON THE ANSWER SHEET.

6. A student with a mass of 67.5 kg determines his weight to be 661 N. The best value for the gravitational field of Earth at this location would be b m/s^2. The value of b is _____. (Round and record the answer to three significant digits.)

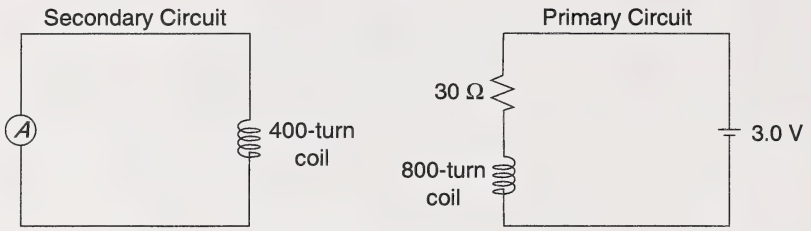
   RECORD YOUR ANSWER ON THE ANSWER SHEET.

7. An 1100 W microwave oven is used for 15.0 minutes every day for one full year (365 d). If the rate charged electricity is \$0.07 per kW • h, then the cost of operating the microwave oven for one year would be \$_____. (Round and record your answer to the nearest cent.)

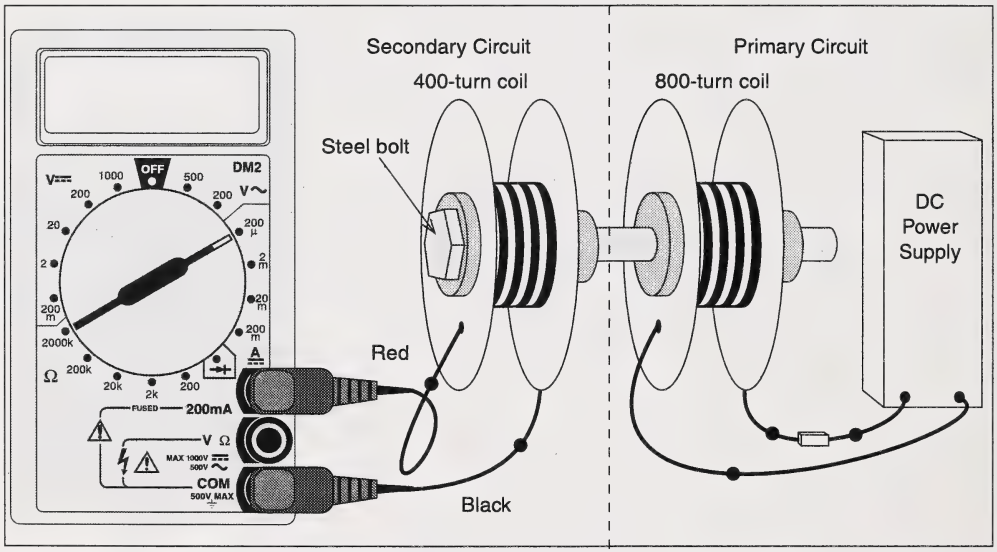
   RECORD YOUR ANSWER ON THE ANSWER SHEET.

Use the following information to answer the next two questions.

A student contructed two separate circuits. One circuit, called the primary circuit, consisted of a 30-Ω power resistor in series with the 800-turn coil and a DC power supply set at 3.0 V. The other circuit, called the secondary circuit, consists of the 400-turn coil in series with the microammeter.



A steel bolt was placed through both coils, as shown in the following diagram.



8. If the resistance of the 800-turn coil was 17 Ω, then the current through the primary circuit should be _____ mA. (Round and record your answer to two significant digits.)

RECORD YOUR ANSWER ON THE ANSWER SHEET.

9. If this device responded in the same way as commercially available models, then you would expect the primary coil to have _____ times the voltage across it as the secondary coil.

RECORD YOUR ANSWER ON THE ANSWER SHEET.

10. If light can travel at 3.00×10^{8} m/s, then the distance it travels in 4.30 light-years is $b \times 10^{w}$ m. The value of b to 3 significant digits is _____.

RECORD YOUR ANSWER ON THE ANSWER SHEET.

11. The correct sequence of the life cycle of a star that will become a neutron star from the list that follows is _____ _____ _____ _____.

    1. giant 2. main sequence star 3. nebula 4. supernova

RECORD YOUR ANSWER ON THE ANSWER SHEET.

12. If a multimeter that is connected to a photovoltaic cell registers a current of 200 mA and a voltage of 1.00 V, the power rating of the photovoltaic cell is $b \times 10^{-w}$ watts. The value of b to 3 significant digits is _____.

RECORD YOUR ANSWER ON THE ANSWER SHEET.

Value

PART C: WRITTEN RESPONSE

22

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Write your answers in the space provided as neatly as possible.
- For full marks, your answers **must show all** pertinent explanations, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences for a written response, and correct units and significant digits for a numerical response.

Start Part C immediately.

(6 marks)

1. You are placed in an emergency situation of having to save someone's life by having to lift up this person who has just slipped off a cliff. List the entire sequence of events in the appropriate order that would take place with respect to your body in terms of the role of your circulatory system and your nervous system in carrying out the appropriate response. Identify structural components in your explanation. **(6 marks; 4 marks for concepts and 2 marks for communication and organization)**

Name of Student _____ Student I.D. # _____

Name of School _____ Date _____

(3 marks) 2. Explain why the process of treating hazardous wastes, at the Alberta Special Waste Treatment plant in Swan Hills, is considered to be environmentally sound.

Use the following information to answer question 3.

Satellites can be used to provide images from space for a variety of applications. Canada is a world leader in this field known as remote sensing. Remote sensing can be used to search for rock formations that might indicate the presence of oil or natural gas. Remote sensing can also be used to provide weather surveillance and to monitor the movement of dangerous icebergs through shipping lanes around Canada's coast.

One type of sensor that is used extensively is know as synthetic aperature radar (SAR). This system bounces microwave radiation off the surface of Earth and then uses the strength of the return signal to determine whether the surface is rough (trees) or smooth (calm water). The radiation used for this purpose has a range of 1.5×10^{9} Hz to 1.0×10^{10} Hz and is able to penetrate cloud cover.

A satellite equipped with SAR could provide detailed information from every part of Canada in only three days if it were maintained at an altitude of 1050 km above Earth's surface.

A satellite equipped with a SAR sensor requires 1.7 kW to operate. When it is eclipsed by Earth (moving through Earth's shadow in darkness) this energy comes directly from the batteries. When it is in sunlight it still requires 1.7 kW for operating but it also requires an additional 3.4 kW to recharge its batteries. A solar array provides the energy when the satellite is in the sunlight.

Name of Student _____ Student I.D. # _____

Name of School _____ Date _____

(2 marks) 3. a. Explain how the satellite is kept in its orbit around Earth even though there is no physical connection (like a wire or metal rod) between Earth and the satellite. Support your answer with concepts from Science 30.

(2 marks) b. Calculate the range of wavelengths used by an SAR sensor.

Name of Student _____	Student I.D. # _____
Name of School _____	Date _____

(2 marks)

c. The microwave radiation produced by the SAR unit can penetrate cloud cover, but will it be able to pass through Earth's magnetic field? After all, if Earth's magnetic field can deflect particles in the solar wind, could microwave radiation be similarly deflected? Explain your answer.

(2 marks)

d. It takes a satellite 105 min to orbit Earth once if its altitude is about 1050 km. The eclipse time (time spent in darkness) for this orbit would be approximately 34 min. Calculate the energy provided by the solar array on this satellite.

Name of Student _____ Student I.D. # _____

Name of School _____ Date _____

(5 marks)

4. Although almost everyone agrees that one of the major problems facing society in the twenty-first century is to ensure a sustainable environment with respect to energy, not everyone has the same opinion on how the environment can be sustained. In a well-organized report compare and contrast the opinions of a student in an industrialized country and a student in a developing country. In your comparison be sure to include the following:

   - definition of a sustainable environment
   - types of energy sources
   - urgency for achieving a sustainable environment

   Marks will be awarded for good communication.

(There is more room for your answer on the next page.)

Name of Student _____ Student I.D. # _____

Name of School _____ Date _____

Name of Student _____ Student I.D. # _____

Name of School _____ Date _____

Science
Data Booklet

Alberta
EDUCATION

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Miscellaneous

Data and Equations

solar constant $= 1360 \text{ watts/m}^2$

$$\% \text{ efficiency} = \frac{\text{output}}{\text{input}} \times 100$$

$$\% \text{ error} = \frac{\text{experimental value} - \text{theoretical value}}{\text{theoretical value}} \times 100$$

$$\text{magnification} = \frac{\text{power of ocular lens}}{} \times \frac{\text{power of objective lens}}{}$$

speed of light $= c = 3.00 \times 10^8 \text{ m/s}$

1 light year $= 9.47 \times 10^{15} \text{ m}$

1 AU = astronomical unit

1 AU $= 1.50 \times 10^{11} \text{ m}$

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

SOME NON-SI UNITS USED WITH SI			
Quantity	**Unit Name**	**Symbol**	**Definition**
Time	minute hour day year	min h d a	1 min = 60 s 1 h = 3600 s 1 d = 86 400 s 1 a = 31 557 600 s
Area	hectare	ha	1 ha = 1 hm^2 = 10 000 m^2
Volume	litre	L	1 L = 1000 cm^3
Mass	metric ton or tonne	t	1 t = 1000 kg = 1 Mg
Pressure	standard atmosphere	atm	1 atm = 101.325 kPa

A SYSTEM OF PREFIXES			
Prefix	**Symbol**	**Factor by Which Base Unit Is Multiplied**	
exa	E	1 000 000 000 000 000 000	$=10^{18}$
peta	P	1 000 000 000 000 000	$=10^{15}$
tera	T	1 000 000 000 000	$=10^{12}$
giga	G	1 000 000 000	$=10^{9}$
*mega	M	1 000 000	$=10^{6}$
*kilo	k	1 000	$=10^{3}$
hecto	h	100	$=10^{2}$
deca	da	10	$=10^{1}$
deci	d	0.1	$=10^{-1}$
centi	c	0.01	$=10^{-2}$
*milli	m	0.001	$=10^{-3}$
*micro	μ	0.000 001	$=10^{-6}$
nano	n	0.000 000 001	$=10^{-9}$
pico	p	0.000 000 000 001	$=10^{-12}$
femto	f	0.000 000 000 000 001	$=10^{-15}$
atto	a	0.000 000 000 000 000 001	$=10^{-18}$

* most commonly used

Kinematics and Dynamics Formulas

$$\vec{v} = \frac{\vec{d}}{t}$$

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

$$\vec{F} = m\vec{a}$$

$$W = Fd$$

$$P = \frac{W}{t}$$

$$F_c = \frac{mv^2}{r}$$

$$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$

$$\vec{d} = \left(\frac{\vec{v}_i + \vec{v}_f}{2}\right)t$$

$$\vec{p} = m\vec{v}$$

$$\frac{\Delta\vec{p}}{\Delta t} = m\Delta\vec{a}$$

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1{}' + m_2\vec{v}_2{}'$$

$$E_p = mgh$$

$$E_k = \frac{1}{2}mv^2$$

$\vec{v}$ = velocity (m/s)
v = speed (m/s)
$\vec{d}$ = displacement (m)
d = distance (m)
t = time (s)
$\vec{a}$ = acceleration (m/s^2)
$\vec{F}$ = force ($kg \bullet m/s^2$ or N)
m = mass (kg)
W = work (N • m or J)
P = power (J/s or watts)
F_c = centripetal force (N)
r = radius (m)
$\vec{p}$ = momentum ($kg \bullet m/s$)
E_p = potential energy (J)
g = acceleration due to gravity ($9.81\ m/s^2$)
h = height (m)
E_k = kinetic energy (J)

Gravitational and Electrical Fields

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$\vec{F}_g = m\vec{g}$$

$$g = \frac{Gm_1}{r^2}$$

$$F_e = \frac{kq_1q_2}{r^2}$$

$$\left|\vec{E}\right| = \frac{\vec{F}_e}{q}$$

$$\left|\vec{E}\right| = \frac{kq_1}{r^2}$$

F_g = force due to gravity (N)
m = mass (kg)
G = gravitational constant = $6.67 \times 10^{-11}\ N \bullet m^2/kg^2$
r = centre-to-centre distance (m)
g = acceleration due to gravity = $9.81\ m/s^2$ or $9.81\ N/kg$
F_e = force due to electrostatic charges (N)
k = Coulomb's law constant = $8.99 \times 10^9\ N \bullet m^2/C^2$
q = amount of electrostatic charge in coulombs (C)
$\left|\vec{E}\right|$ = electric field strength (N/C) or (V/m)

Related values:

Mass of Earth = 5.97×10^{24} kg	Mass of sun = 1.99×10^{30} kg
Radius of Earth = 6.37×10^6 m	Elementary charge = 1.60×10^{-19} C (charge of a proton or electron)

Electricity

Formulas

For resistances connected in series

$R_T = R_1 + R_2 + R_3 + \ldots R_n$

R = resistance in ohms (Ω)

For resistances connected in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \frac{1}{R_n}$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$V = IR$

$E = Pt$

P = power (watts)

I = current in amperes (A)

V = voltage in volts (V)

E = energy (J)

t = time in seconds (s)

Transformers

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

N = number of turns

p = primary

s = secondary

Output Voltage × Primary Turns = Input Voltage × Secondary Turns

Output Current × Secondary Turns = Input Current × Primary Turns

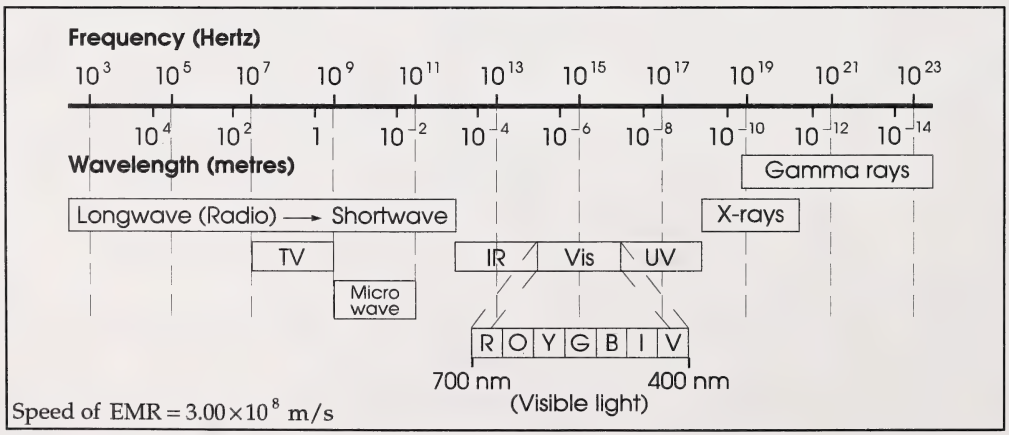
Related values: 1 kWh = 3.60×10^6 J

Waves

Wave Formula

$v = f\lambda$ v = speed of wave (m/s) f = frequency (/s or Hz) λ = wavelength (m)

Electromagnetic Spectrum



Electrochemistry

ACTIVITY SERIES (for 1.0 mol/L solution at 25°C)

Reduction Half-Reaction

Metal ions get more stable ↓

$Au^{3+}_{(aq)}$	+	$3e^-$	→	$Au_{(s)}$	
$Ag^{+}_{(aq)}$	+	$2e^-$	→	$Ag_{(s)}$	
$Hg^{2+}_{(aq)}$	+	e^-	→	$Hg_{(l)}$	
$Cu^{2+}_{(aq)}$	+	$2e^-$	→	$Cu_{(s)}$	
$2H^{+}_{(aq)}$	+	$2e^-$	→	$H_{2(g)}$	
$Pb^{2+}_{(aq)}$	+	$2e^-$	→	$Pb_{(s)}$	
$Sn^{2+}_{(aq)}$	+	$2e^-$	→	$Sn_{(s)}$	
$Ni^{2+}_{(aq)}$	+	$2e^-$	→	$Ni_{(s)}$	
$Cd^{2+}_{(aq)}$	+	$2e^-$	→	$Cd_{(s)}$	
$Fe^{2+}_{(aq)}$	+	$2e^-$	→	$Fe_{(s)}$	
$Cr^{2+}_{(aq)}$	+	$2e^-$	→	$Cr_{(s)}$	
$Zn^{2+}_{(aq)}$	+	$2e^-$	→	$Zn_{(s)}$	
$Al^{3+}_{(aq)}$	+	$3e^-$	→	$Al_{(s)}$	
$Mg^{2+}_{(aq)}$	+	$2e^-$	→	$Mg_{(s)}$	
$Na^{+}_{(aq)}$	+	e^-	→	$Na_{(s)}$	
$Ca^{2+}_{(aq)}$	+	$2e^-$	→	$Ca_{(s)}$	
$Li^{+}_{(aq)}$	+	e^-	→	$Li_{(s)}$	

↑ Metal atoms get more stable

Thermodynamics

HEAT CAPACITIES OF SOME COMMON COMPOUNDS	
Compound	**Specific Heat Capacity (J/g°C) or kJ/kg°C**
Water (liquid)	4.19
Methanol	2.55
Ethanol	2.46
Hexane	2.26
Water (solid)	2.01
Water (gas)	2.01
Toluene	1.80
Sulphuric acid	1.13

HEATS OF FUSION OF VARIOUS SUBSTANCES	
Substances	**Heat of Fusion (J/g) or kJ/kg**
Water	333
Sulphuric acid	163
Hexane	152
Ethanol	109
Methanol	100
Toluene	72

HEATS OF VAPORIZATION OF VARIOUS SUBSTANCES	
Substances	**Heat of Vaporization (J/g) or kJ/kg**
Water	2260
Methanol	1076
Ethanol	855
Sulphuric acid	510
Toluene	363
Hexane	335

STANDARD HEATS OF FORMATION AT 298.15 K (25°C)		
Name	**Formula**	**ΔH_f° (kJ/mol)**
ammonia	$NH_{3(g)}$	– 46.1
benzene	$C_6H_{6(l)}$	+ 49.0
butane	$C_4H_{10(g)}$	– 126.5
calcium carbonate	$CaCO_{3(s)}$	– 1206.9
calcium hydroxide	$Ca(OH)_{2(s)}$	– 986.1
carbon dioxide	$CO_{2(g)}$	– 393.5
carbon monoxide	$CO_{(g)}$	– 110.5
ethane	$C_2H_{6(g)}$	– 84.7
ethanoic acid (acetic acid)	$CH_3COOH_{(l)}$	– 484.5
ethanol	$C_2H_5OH_{(l)}$	– 277.1
ethene (ethylene)	$C_2H_{4(g)}$	+ 52.3
ethyne (acetylene)	$C_2H_{2(g)}$	+ 226.7
glucose	$C_6H_{12}O_{6(s)}$	– 1273.1
hydrogen sulphide	$H_2S_{(g)}$	– 20.6
methanal (formaldehyde)	$CH_2O_{(g)}$	– 115.9
methane	$CH_{4(g)}$	– 74.8
methanol	$CH_3OH_{(l)}$	– 239.0
octane	$C_8H_{18(l)}$	– 250.0
pentane	$C_5H_{12(l)}$	– 146.4
propane	$C_3H_{8(g)}$	– 103.8
sucrose	$C_{12}H_{22}O_{11(s)}$	– 2225.5
sulphur dioxide	$SO_{2(g)}$	– 296.8
sulphur trioxide (vapour)	$SO_{3(g)}$	– 395.7
water (liquid)	$H_2O_{(l)}$	– 285.8
water (vapour)	$H_2O_{(g)}$	– 241.8

ΔH_f^o for elements is zero

Energy Formulas

$Q = mc\Delta t$

$\Delta H_{fus} = \frac{Q}{m}$

$\Delta H_{vap} = \frac{Q}{m}$

$\Delta H = \Sigma \Delta H_f^\circ (\text{products}) - \Sigma \Delta H_f^\circ (\text{reactants})$

$E = \Delta m c^2 \left(c = 3.00 \times 10^8 \text{ m/s}\right)$

Q = quantity of heat energy (kJ)
m = mass (kg)
c = specific heat capacity (kJ/kg°C)
Δt = change in temperature (°C)
ΔH_{fus} = heat of fusion (kJ/kg)
ΔH_{vap} = heat of vaporization (kJ/kg)
ΔH = change in heat (kJ)
ΔH_f° = standard heat of formation (kJ/mol)
Σ = the sum of
ΔE = change in energy (J)

Periodic Chart of the

1	2	3	4	5	6	7	8	9
IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	

1 **H** hydrogen **1.01** H^+ hydrogen								
3 **Li** lithium **6.94** Li^+ lithium	4 **Be** beryllium **9.01** Be^{2+} beryllium							
11 **Na** sodium **22.99** Na^+ sodium	12 **Mg** magnesium **24.31** Mg^{2+} magnesium							
19 **K** potassium **39.10** K^+ potassium	20 **Ca** calcium **40.08** Ca^{2+} calcium	21 **Sc** scandium **44.96** Sc^{3+} scandium	22 **Ti** titanium **47.90** Ti^{4+} titanium(IV) Ti^{3+} titanium(III)	23 **V** vanadium **50.94** V^{5+} vanadium(V) V^{4+} vanadium(IV)	24 **Cr** chromium **52.00** Cr^{3+} chromium(III) Cr^{2+} chromium(II)	25 **Mn** manganese **54.94** Mn^{2+} manganese(II) Mn^{4+} manganese(IV)	26 **Fe** iron **55.85** Fe^{3+} iron(III) Fe^{2+} iron(II)	27 **Co** cobalt **58.93** Co^{2+} cobalt(II) Co^{3+} cobalt(III)
37 **Rb** rubidium **85.47** Rb^+ rubidium	38 **Sr** strontium **87.62** Sr^{2+} strontium	39 **Y** yttrium **88.91** Y^{3+} yttrium	40 **Zr** zirconium **91.22** Zr^{4+} zirconium	41 **Nb** niobium **92.91** Nb^{5+} niobium(V) Nb^{3+} niobium(III)	42 **Mo** molybdenum **95.94** Mo^{6+} molybdenum	43 **Tc** technetium **(98.91)** Tc^{7+} technetium	44 **Ru** ruthenium **101.07** Ru^{3+} ruthenium(III) Ru^{4+} ruthenium(IV)	45 **Rh** rhodium **102.91** Rh^{3+} rhodium
55 **Cs** cesium **132.91** Cs^+ cesium	56 **Ba** barium **137.33** Ba^{2+} barium	57–71	72 **Hf** hafnium **178.49** Hf^{4+} hafnium	73 **Ta** tantalum **180.95** Ta^{5+} tantalum	74 **W** tungsten **183.85** W^{6+} tungsten	75 **Re** rhenium **186.21** Re^{7+} rhenium	76 **Os** osmium **190.20** Os^{4+} osmium	77 **Ir** iridium **192.22** Ir^{4+} iridium
87 **Fr** francium **(223.02)** Fr^+ francium	88 **Ra** radium **(226.03)** Ra^{2+} radium	89–103	104 **Unq** unnilquadium **(266.11)**	105 **Unp** unnilpentium **(262.11)**	106 **Unh** unnilhexium **(263.12)**	107 **Uns** unnilseptium **(262.12)**	108 **Uno** unniloctium **(265)**	109 **Une** unnilennium **(266)**

57 **La** lanthanum **138.91** La^{3+} lanthanum	58 **Ce** cerium **140.12** Ce^{3+} cerium	59 **Pr** praseodymium **140.91** Pr^{3+} praseodymium	60 **Nd** neodymium **144.24** Nd^{3+} neodymium	61 **Pm** promethium **(144.91)** Pm^{3+} promethium	62 **Sm** samarium **150.35** Sm^{3+} samarium(III) Sm^{2+} samarium(II)
89 **Ac** actinium **(277.03)** Ac^{3+} actinium	90 **Th** thorium **(232.04)** Th^{4+} thorium	91 **Pa** protactinium **(231.04)** Pa^{5+} protactinium(V) Pa^{4+} protactinium(IV)	92 **U** uranium **238.03** U^{6+} uranium(VI) U^{4+} uranium(IV)	93 **Np** neptunium **(237.05)** Np^{5+} neptunium	94 **Pu** plutonium **(244.06)** Pu^{4+} plutonium(IV) Pu^{6+} plutonium(VI)

Table of Polyatomic Ions and Elements

Polyatomic ions				Elements	
acetate	CH_3COO^-	nitrate	NO_3^-	astatine	At_2
ammonium	NH_4^+	nitrite	NO_2^-	bromine	Br_2
benzoate	$C_6H_5COO^-$	permanganate	MnO_4^-	chlorine	Cl_2
borate	BO_3^{3-}	phosphate	PO_4^{3-}	fluorine	F_2
carbonate	CO_3^{2-}	hydrogen phosphate	HPO_4^{2-}	hydrogen	H_2
hydrogen carbonate	HCO_3^-	dihydrogen phosphate	$H_2PO_4^-$	iodine	I_2
chlorate	ClO_3^-	silicate	SiO_3^{2-}	nitrogen	N_2
hypochlorite	ClO^-	sulphate	SO_4^{2-}	oxygen	O_2
chromate	CrO_4^{2-}	sulphite	SO_3^{2-}	phosphorus	P_4
dichromate	$Cr_2O_7^{2-}$	hydrogen sulphide	HS^-	sulphur	S_8
cyanide	CN^-	hydrogen sulphate	HSO_4^-		
hydroxide	OH^-	hydrogen sulphite	HSO_3^-		

Elements and Ions

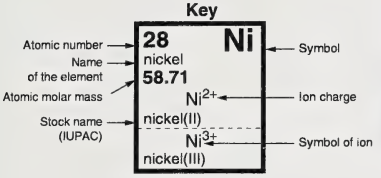
10	11	12	13	14	15	16	17	18
VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA or O

Note:
The legend at the right denotes the physical state of the elements at 101.325 kPa and 298.15 K (25°C).

Legend for the elements

Solid	Liquid	Gas
Seldom forms ions		

Key



Based on $^{12}_{6}C$
Most stable or common ion is listed above dotted line
( ) Indicates mass of the most stable isotope

1 H								2 He
hydrogen								helium
1.01								4.00
							H⁻	
							hydride	
								He
								helium
			5 B	6 C	7 N	8 O	9 F	10 Ne
			boron	carbon	nitrogen	oxygen	fluorine	neon
			10.81	12.01	14.01	16.00	19.00	20.17
			B	C	N³⁻	O²⁻	F⁻	Ne
			boron	carbon	nitride	oxide	fluoride	neon
			13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
			aluminum	silicon	phosphorus	sulphur	chlorine	argon
			26.98	28.09	30.97	32.06	35.45	39.95
			Al³⁺	Si	P³⁻	S²⁻	Cl⁻	Ar
			aluminum	silicon	phosphide	sulphide	chloride	argon
28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton
58.71	63.55	65.38	69.72	72.59	74.92	78.96	79.90	83.80
Ni²⁺	Cu²⁺			Sn⁴⁺	Sb³⁺			
nickel(II)	copper(II)			tin(IV)	antimony(III)			
Ni³⁺	Cu⁺	Zn²⁺	Ga³⁺	Sn²⁺	Sb⁵⁺	Se²⁻	Br⁻	Kr
nickel(III)	copper(I)	zinc	gallium	tin(II)	antimony(V)	selenide	bromide	krypton
46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon
106.40	107.87	112.41	114.82	118.69	121.75	127.60	126.90	131.30
Pd²⁺				Sn⁴⁺	Sb³⁺			
palladium(II)				tin(IV)	antimony(III)			
Pd⁴⁺	Ag⁺	Cd²⁺	In³⁺	Sn²⁺	Sb⁵⁺	Te²⁻	I⁻	Xe
palladium(IV)	silver	cadmium	indium	tin(II)	antimony(V)	telluride	iodide	xenon
78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon
195.09	196.97	200.59	204.37	207.19	208.98	(208.98)	(209.98)	(222)
Pt⁴⁺	Au³⁺	Hg²⁺	Tl⁺	Pb²⁺	Bi³⁺	Po²⁺		
platinum(IV)	gold(III)	mercury(II)	thallium	lead(II)	bismuth(III)	polonium(II)		
Pt²⁺	Au⁺	Hg⁺	Tl³⁺	Pb⁴⁺	Bi⁵⁺	Po⁴⁺	At⁻	Rn
platinum(II)	gold(I)	mercury(I)	thallium(III)	lead(IV)	bismuth(V)	polonium(IV)	astatide	radon

63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium
151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97
Eu³⁺							Yb³⁺	
europium(III)							ytterbium(III)	
Eu²⁺	Gd³⁺	Tb³⁺	Dy³⁺	Ho³⁺	Er³⁺	Tm³⁺	Yb²⁺	Lu²⁺
europium(II)	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium(II)	lutetium
95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium
(243.06)	(247.07)	(247.07)	(242.06)	(252.08)	(257.10)	(258.10)	(259.10)	(260.11)
Am³⁺		Bk³⁺				Md²⁺	No²⁺	
americium(III)		berkelium(III)				mendelevium(II)	nobelium(II)	
Am⁴⁺	Cm³⁺	Bk⁴⁺	Cf³⁺	Es³⁺	Fm³⁺	Md³⁺	No³⁺	Lr³⁺
americium(IV)	curium	berkelium(IV)	californium	einsteinium	fermium	mendelevium(III)	nobelium(III)	lawrencium

Nuclear Chemistry

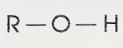
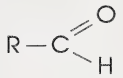
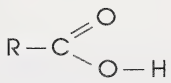
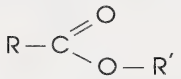
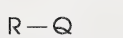
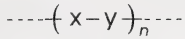
MASSES OF SELECTED NUCLIDES AND SUBATOMIC PARTICLES			
Nuclide or Particle	**Mass $(10^{-3}$ kg/mol$)$**	**Nuclide or Particle**	**Mass $(10^{-3}$ kg/mol$)$**
electron, ${}^{0}_{-1}e$	0.000 549	sulphur–31, ${}^{31}_{16}S$	30.970 77
positron, ${}^{0}_{+1}e$	0.000 549	potassium–40, ${}^{40}_{19}K$	39.953 57
proton, ${}^{1}_{1}H$	1.007 28	rubidium–90, ${}^{90}_{37}Rb$	89.894 27
neutron, ${}^{1}_{0}n$	1.008 67	krypton–92, ${}^{92}_{36}Kr$	91.906 01
deuterium, ${}^{2}_{1}H$	2.013 55	strontium–95, ${}^{95}_{38}Sr$	94.898 47
helium–3, ${}^{3}_{2}He$	3.014 93	ruthenium–107, ${}^{107}_{44}Ru$	106.885 98
tritium, ${}^{3}_{1}H$	3.015 50	barium–141, ${}^{141}_{56}Ba$	140.883 40
alpha particle (helium nucleus), ${}^{4}_{2}He$	4.001 50	cesium–144, ${}^{144}_{55}Cs$	143.901 18
beryllium–7, ${}^{7}_{4}Be$	7.014 70	lanthanum–146, ${}^{146}_{57}La$	145.894 14
beryllium–8, ${}^{8}_{4}Be$	8.003 11	lead–206, ${}^{206}_{82}Pb$	205.929 5
boron–8, ${}^{8}_{5}B$	8.021 86	lead–208, ${}^{208}_{82}Pb$	207.931 6
nitrogen–13, ${}^{13}_{7}N$	13.001 90	polonium–210, ${}^{210}_{84}Po$	209.936 8
nitrogen–14, ${}^{14}_{7}N$	13.999 231	polonium–218, ${}^{218}_{84}Po$	217.962 8
carbon–14, ${}^{14}_{6}C$	13.999 95	radon–222, ${}^{222}_{86}Rn$	221.970 3
oxygen–15, ${}^{15}_{8}O$	14.998 67	radium–226, ${}^{226}_{88}Ra$	225.977 1
fluorine–17, ${}^{17}_{9}F$	16.997 15	thorium–230, ${}^{230}_{90}Th$	229.983 7
neon–20, ${}^{20}_{10}Ne$	19.986 95	uranium–235, ${}^{235}_{92}U$	234.993 4
phosphorus–31, ${}^{31}_{15}P$	30.965 53	plutonium–239, ${}^{239}_{94}Pu$	239.000 6

ELEMENTS FOR RADIOACTIVE DATING		
Radioisotope	**Approximate Half-life (a)**	**Decay Product**
${}^{14}_{6}C$ (carbon–14)	5.73×10^{3}	${}^{14}_{7}N$ (nitrogen–14)
${}^{40}_{19}K$ (potassium–40)	1.28×10^{9}	${}^{40}_{18}Ar$ (argon–40)
${}^{87}_{37}Rb$ (rubidium–87)	4.86×10^{10}	${}^{87}_{38}Sr$ (strontium–87)
${}^{235}_{92}U$ (uranium–235)	7.13×10^{8}	${}^{207}_{82}Pb$ (lead–207)
${}^{238}_{92}U$ (uranium–238)	4.51×10^{9}	${}^{206}_{82}Pb$ (lead–206)

Organic Chemistry

HOMOLOGOUS SERIES OF ALKANES (state at room temperature and pressure)	
Name	**Chemical Formula**
methane	$CH_{4(g)}$
ethane	$C_2H_{6(g)}$
propane	$C_3H_{8(g)}$
butane	$C_4H_{10(g)}$
pentane	$C_5H_{12(l)}$
hexane	$C_6H_{14(l)}$
heptane	$C_7H_{16(l)}$
octane	$C_8H_{18(l)}$
nonane	$C_9H_{20(l)}$
decane	$C_{10}H_{22(l)}$

PREFIXES FOR MOLECULAR COMPOUNDS	
1 = mono-	6 = hexa-
2 = di-	7 = hepta-
3 = tri-	8 = octa-
4 = tetra-	9 = ennea- (nona-)
5 = penta-	10 = deca-

FUNCTIONAL GROUPS	
	alcohol
	aldehyde
	carboxylic acid
	ketone
	ester
	halide
	polymers
R is usually a carbon group Q stands for a halogen x-y is a monomer unit	

Solutions

SOLUBILITY OF SOME COMMON IONIC COMPOUNDS IN WATER AT 298.15 K (25°C)								
Ion	**Group 1** NH_4^+ $H^+ (H_3O^+)$	ClO_3^- NO_3^- ClO_4^-	CH_3COO^-	Cl^- Br^- I^-	SO_4^{2-}	S^{2-}	OH^-	PO_4^{3-} SO_3^{2-} CO_3^{2-}
Solubility greater than or equal to 0.1 mol/L (very soluble)	all	all	most	most	most	Group 1 Group 2 NH_4^+	Group 1 NH_4^+ Sr^{2+} Ba^{2+} Tl^+	Group 1 NH_4^+
Solubility less than or equal to 0.1 mol/L (slightly soluble)	none	none	Ag^+	Ag^+ Pb^{2+} Hg^+ Cu^+ Tl^+	Ca^{2+} Sr^{2+} Ba^{2+} Ra^{2+} Pb^{2+} Ag^+	most	most	most

Stoichiometry and Solution Formulas

$n = \frac{m}{M}$

$C = \frac{n}{V}$

$C_1 V_1 = C_2 V_2$

$n_r = n_g \times \frac{\text{coefficient}_r}{\text{coefficient}_g}$

$C = \text{concentration}(\text{mol/L})$
$m = \text{mass}(\text{g})$
$M = \text{molar mass}(\text{g/mol})$
$n = \text{number of moles}(\text{mol})$
$V = \text{volume}(\text{L})$
r = required substance
g = given substance

METHODS OF EXPRESSING CONCENTRATION			
Moles per Litre (mol/L)	**Parts per Million (ppm)**	**Percent Mass/Volume (% m/V)**	**Percent by Volume (% V/V)**
$\frac{\text{mol solute}}{\text{L solution}}$	$\frac{\text{g solute}}{\text{g solution}} \times 10^6$	$\frac{\text{g solute}}{\text{mL solution}} \times 100$	$\frac{\text{mL solute}}{\text{mL solution}} \times 100$

COLOUR CHART OF COMMON AQUEOUS IONS					
Ion	**Symbol**	**Colour**	**Ion**	**Symbol**	**Colour**
chromate	CrO_4^{2-}	yellow	dichromate	$Cr_2O_7^{2-}$	orange
chromium(III)	Cr^{3+}	green	iron(II)	Fe^{2+}	pale green
chromium(II)	Cr^{2+}	blue	iron(III)	Fe^{3+}	pale yellow
cobalt(II)	Co^{2+}	pink	manganese(II)	Mn^{2+}	pale pink
copper(I)	Cu^{+}	green	permanganate	MnO_4^{-}	purple
copper(II)	Cu^{2+}	blue			

Acids and Bases

Acid Formulas

$\text{pH} = -\log_{10}\left[H_3O^{+}_{(aq)}\right] \quad \left[H_3O^{+}_{(aq)}\right] = \text{antilog}_{10}\left[-\text{pH}\right]$

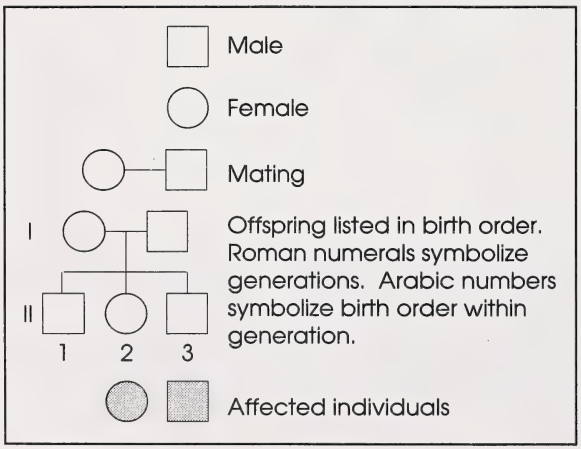
IUPAC RULES FOR NAMING ACIDS				
		Example		
Ionic Name	**Acid Name**	**Formula**	**Ionic Name**	**Acid Name**
hydrogen –ide	hydro –ic acid	$HCl_{(aq)}$	hydrogen chloride	hydrochloric acid
hydrogen –ate	–ic acid	$H_3PO_{4(aq)}$	hydrogen phosphate	phosphoric acid
hydrogen –ite	–ous acid	$H_3PO_{3(aq)}$	hydrogen phosphite	phosphorous acid

RELATIVE STRENGTHS OF ACIDS AND BASES AT 0.10 mol/L AND 298.15 K (25°C)		
Acid Name	**Acid Formula**	**Conjugate Base Formula**
hydrochloric acid	$HCl_{(aq)}$	$Cl^{-}{}_{(aq)}$
sulphuric acid	$H_2SO_{4(aq)}$	$HSO_4{}^{-}{}_{(aq)}$
nitric acid	$HNO_{3(aq)}$	$NO_3{}^{-}{}_{(aq)}$
hydronium ion	$H_3O^{+}{}_{(aq)}$	$H_2O_{(l)}$
oxalic acid	$HOOCCOOH_{(aq)}$	$HOOCCOO^{-}{}_{(aq)}$
sulphurous acid $(SO_2 + H_2O)$	$H_2SO_{3(aq)}$	$HSO_3{}^{-}{}_{(aq)}$
hydrogen sulphate ion	$HSO_4{}^{-}{}_{(aq)}$	$SO_4{}^{2-}{}_{(aq)}$
phosphoric acid	$H_3PO_{4(aq)}$	$H_2PO_4{}^{-}{}_{(aq)}$
orange IV	$HOr_{(aq)}$	$Or^{-}{}_{(aq)}$
nitrous acid	$HNO_{2(aq)}$	$NO_2{}^{-}{}_{(aq)}$
hydrofluoric acid	$HF_{(aq)}$	$F^{-}{}_{(aq)}$
methanoic acid	$HCOOH_{(aq)}$	$HCOO^{-}{}_{(aq)}$
methyl orange	$HMo_{(aq)}$	$Mo^{-}{}_{(aq)}$
benzoic acid	$C_6H_5COOH_{(aq)}$	$C_6H_5COO^{-}{}_{(aq)}$
ethanoic (acetic) acid	$CH_3COOH_{(aq)}$	$CH_3COO^{-}{}_{(aq)}$
carbonic acid $(CO_2 + H_2O)$	$H_2CO_{3(aq)}$	$HCO_3{}^{-}{}_{(aq)}$
bromothymol blue	$HBb_{(aq)}$	$Bb^{-}{}_{(aq)}$
hydrosulphuric acid	$H_2S_{(aq)}$	$HS^{-}{}_{(aq)}$
phenolphthalein	$HPh_{(aq)}$	$Ph^{-}{}_{(aq)}$
boric acid	$H_3BO_{3(aq)}$	$H_2BO_3{}^{-}{}_{(aq)}$
ammonium ion	$NH_4{}^{+}{}_{(aq)}$	$NH_{3(aq)}$
hydrogen carbonate ion	$HCO_3{}^{-}{}_{(aq)}$	$CO_3{}^{2-}{}_{(aq)}$
indigo carmine	$HIc_{(aq)}$	$Ic^{-}{}_{(aq)}$
water (55.5 mol/L)	$H_2O_{(l)}$	$OH^{-}{}_{(aq)}$

ACID-BASE INDICATORS AT 298.15 K (25°C)			
Indicator	**Abbreviation**	**pH Range**	**Colour Change As pH Increases**
methyl violet	HMv	0.0 – 1.6	yellow to blue
thymol blue	H_2Tb	1.2 – 2.8	red to yellow
thymol blue	HTb^-	8.0 – 9.6	yellow to blue
orange IV	HOr	1.4 – 2.8	red to yellow
methyl orange	HMo	3.2 – 4.4	red to yellow
bromocresol green	HBg	3.8 – 5.4	yellow to blue
litmus	HLt	4.5 – 8.3	red to blue
methyl red	HMr	4.8 – 6.0	red to yellow
chlorophenol red	HCh	5.2 – 6.8	yellow to red
bromothymol blue	HBb	6.0 – 7.6	yellow to blue
phenol red	HPr	6.6 – 8.0	yellow to red
phenolphthalein	HPh	8.2 – 10.0	colourless to pink
thymolphthalein	HTh	9.4 – 10.6	colourless to blue
alizarin yellow R	HAy	10.1 – 12.0	yellow to red
indigo carmine	HIc	11.4 – 13.0	blue to yellow
1,3,5-trinitrobenzene	HNb	12.0 – 14.0	colourless to orange

Genetics

Pedigree Chart



ABBREVIATIONS FOR NITROGEN BASES	
Nitrogen Base	**Abbreviation**
Adenine	A
Cytosine	C
Guanine	G
Thymine	T
Uracil	U

Scoring Guides

SCORING GUIDE FOR KNOWLEDGE	
Score	**Scoring Descriptions**
4 **Standard of Excellence**	The response is **well organized** and addresses **all** the major points of the question. **Relevant** scientific, technological, and/or societal concepts and examples are identified and interraltionships are **explicit**. The descriptions and/or explanations of these concepts are **correct**, **well organized**, and **reflect thorough understanding** and **logical consistency of thought**. The student uses complete sentences that make **effective** use of scientific vocabulary. When appropriate, suitable **metaphors**, **similes**, diagrams, and/or sketches are used to illustrate descriptions and/or explanations.
3	The response is **organized** and addresses **most** of the major points of the question. **Relevant** scientific, technological, and/or societal concepts and examples are **identified** and interrelationships are **evident**. The descriptions and/or explanations of these concepts are **organized** and **reflect correct understanding**. The student uses complete sentences that employ **correct** scientific vocabulary. When appropriate, suitable diagrams or sketches are used.
2 **Acceptable Standard**	The response addresses **some** of the major points of the question. **Relevant** scientific, technological, and/or societal concepts and examples are **identified**, but **few** interrelationships are shown. The descriptions and/or explanations of these concepts are **superficial** and **somewhat disorganized**. The student uses complete sentences but the **use of appropriate scientific vocabulary is inconsistent**.
1	The response addresses **few** major points of the question. Concepts are **identified** but **interrelationships are not evident**. The student **superficially** describes the concepts in sentences but **organizational skills and scientific vocabulary are minimal**.
0	The response does not address any of the major points of the question at an **appropriate level** for a 30-level course.

SCORING GUIDE FOR SKILLS	
Score	**Scoring Descriptions**
4 **Standard of Excellence**	The problem is **thoroughly understood**. An **appropriate** and **practical** design is presented. The data are **accurately** and **completely** analysed. **Accurate** interpretations and conclusions are made, **based on an analysis of the data**. The evaluation of the overall study is based on a **thorough understanding** of the principles of scientific inquiry.
3	The problem is **well understood**. An **appropriate** and **somewhat practical** design is presented. The data are **completely** analysed. Interpretations and conclusions are made **based on an analysis of the data**. The evaluation of the overall study is based on a **correct understanding** of the principles of scientific inquiry.
2 **Acceptable Standard**	The problem is **understood**. The design is **generally appropriate**, or a **practical** procedure with **some omissions or errors** is presented. The data are **partially** analysed. Interpretations and conclusions are made **generally based on an analysis of the data**. The evaluation of the overall study is based on a **generally correct understanding** of the principles of scientific inquiry.
1	The problem is **poorly understood**. The design is **incomplete**, or an **impractical** procedure with **major omissions or errors** is presented. The data are **incorrectly** analysed. Interpretations and conclusions are **incorrect** or are **not based on an analysis of the data**. The evaluation study is based on a **superficial understanding** of the principles of scientific inquiry.
0	The response does not address any of the major points of the question at an **appropriate level** for a 30-level course.

SCORING GUIDE FOR STS	
Score	**Scoring Descriptions**
4 **Standard of Excellence**	The design and function of the technological device are **clearly explained**. The interrelationships among science, technology, and society are **thoroughly understood**. Risks and benefits are **thoroughly evaluated**. **Insightful** and **convincing** arguments are used to support a decision or judgement and **a range of viewpoints** is considered.
3	The design and function of the technological device are **explained**. The interrelationships among science, technology, and society are **understood**. Risks and benefits are **evaluated**. **Clear** and **logical** arguments are used to support a decision or judgement and **alternative points-of-view** are considered.
2 **Acceptable Standard**	The design and function of the technological devise are **described**. The interrelationships among science, technology, and society are **generally understood**. Risks and benefits are **listed**. **Logical** arguments are used to support a decision or judgement and **polar points of view** are considered.
1	The design and function of the technological device are **incorrectly described**. The interrelationships among science, technology, and society are **poorly understood**. **Few** risks and benefits are **listed**. **Poorly formed** arguments are used to support a decision or judgement and **only one point of view** is considered.
0	The response does not address any of the major points of the question at an **appropriate level** for a 30-level course.

TEACHER QUESTIONNAIRE FOR SCIENCE 30

This is a course designed in a new distance-learning format, so we are interested in your responses. Your constructive comments will be greatly appreciated so that a future revision may incorporate any necessary improvements.

Teacher's Name _____ Area of Expertise _____

School Name _____ Date _____

Design

1. The modules follow a definite systematic design. Did you find it easy to follow?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

2. Did your observations reveal that the students found the design easy to follow?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

3. Did you find the Learning Facilitator's Manual helpful?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

4. Part of the design involves stating the objectives in student terms. Do you feel this helped the students understand what they were going to learn?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

5. The Learning Facilitator's Manual contains Assignment answers and a sample test. Did you find these helpful?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

6. Did the Follow-up Activities prove to be helpful?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

7. Were students motivated to try these Follow-up Activities?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

8. Suggestions for computer and video activities are included in the course. Were your students able to use these activities?

   ❑ Yes ❑ No Comment on the lines below.

   _____

   _____

9. Were the assignments appropriate?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

10. Did you fax assignments? ❑ Yes ❑ No

11. If you did fax, did you get satisfactory results from using this procedure?

    ❑ Yes ❑ No If no, give details.

    _____

    _____

Instruction

1. Did you find the instruction clear?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

2. Did your observations reveal that the students found the instruction interesting?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

3. Did you find the instruction adequate?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

4. Was the reading level appropriate?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

5. Was the work load adequate?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

6. Was the content accurate and current?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

7. Did the content flow consistently and logically?

❑ Yes ❑ No If no, give details.

_____

_____

8. Was the transition between booklets smooth?

❑ Yes ❑ No If no, give details.

_____

_____

9. If applicable, was the transition between print and other media smooth?

❑ Yes ❑ No If no, give details.

_____

_____

Additional Comments

_____

_____

_____

_____

_____

_____

_____

_____

Thanks for taking the time to complete this survey. Your feedback is important to us.

Fax Number: 674-6686

Instructional Design and Development
Alberta Distance Learning Centre
Box 4000
Barrhead, Alberta
T7N 1P4

Note: Please ensure that each of your students has completed and forwarded a copy of the Course Survey.

N.L.C./B.N.C.
3 3286 50153 0956

Science 30
Learning Facilitator's Manual
1995
LRDC
Producer